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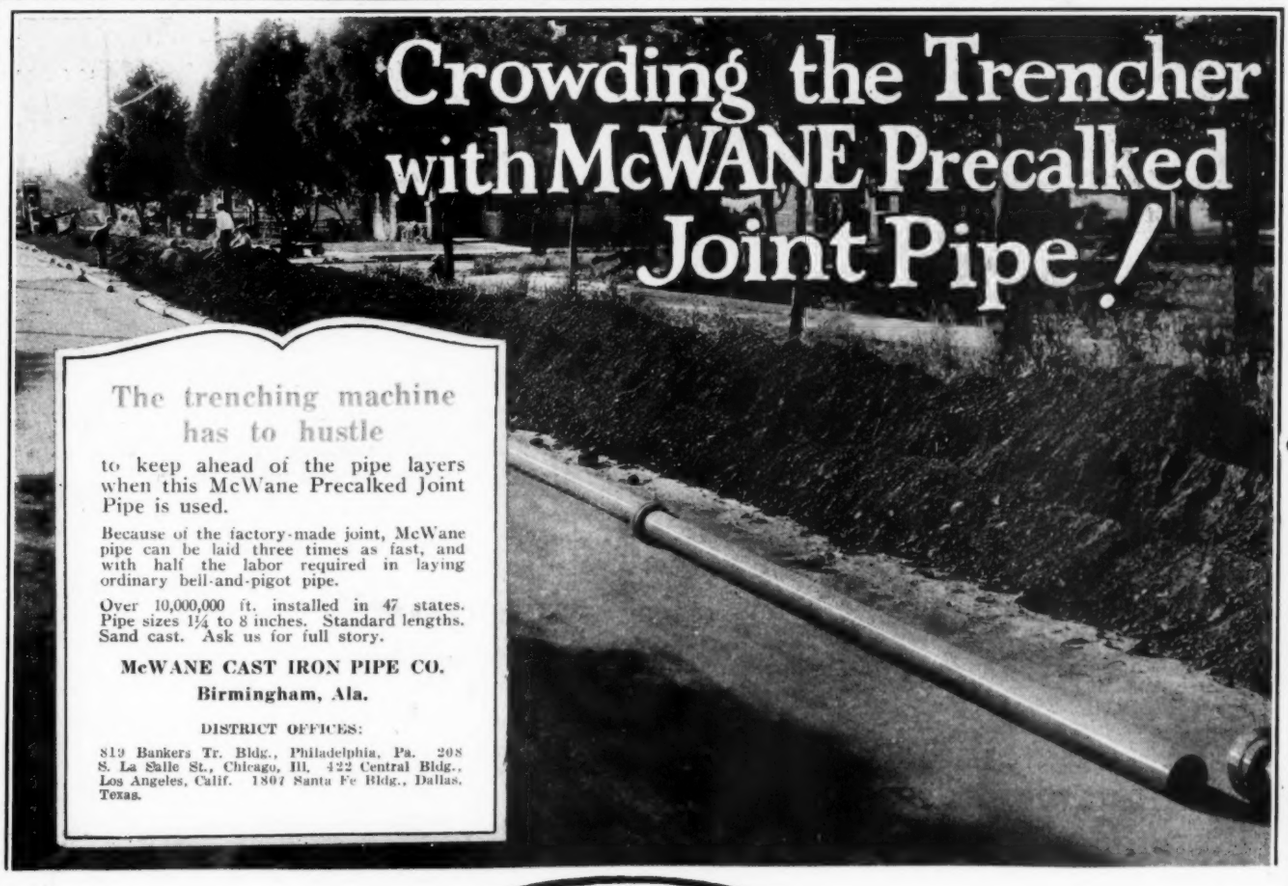
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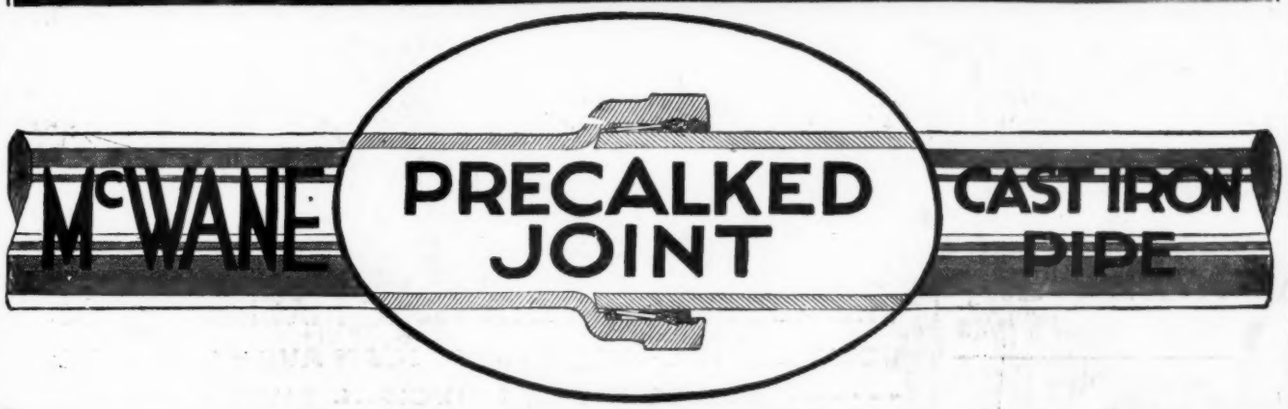

SEPTEMBER, 1926

REPAIRING WORN OUT ROADS
WITH AN AUSTIN LEANING WHEEL MOTOR GRADER

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Illustration No. 1 shows a typical worn out stone road over which it is impossible to drive in comfort at even a most conservative rate of speed. In illustration No. 2 the rear scarifier is loosening the surface from shoulder to shoulder. In No. 3 the blade is being used to level the scarified surface; the leaning front wheels, an exclusive Austin feature, enabling the blade to handle a full load without forcing the front end of the machine into the ditch. Illustration No. 4 shows the smooth surface of the finished road, which is once more ready for high speed traffic.

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SEPTEMBER, 1926

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CITY COUNTY STATE
A Combination of "MUNICIPAL JOURNAL" and "CONTRACTING"
Vol. 57 September, 1926 No. 8

Some Small Water Purification Plants

Well and surface waters of eighteen of the thirty-five plants in Jefferson County, Alabama, serving more than fifty persons receive some treatment. Details of some small filter and chlorination plants.

By W. A. Hardenbergh and K. W. Grimley*

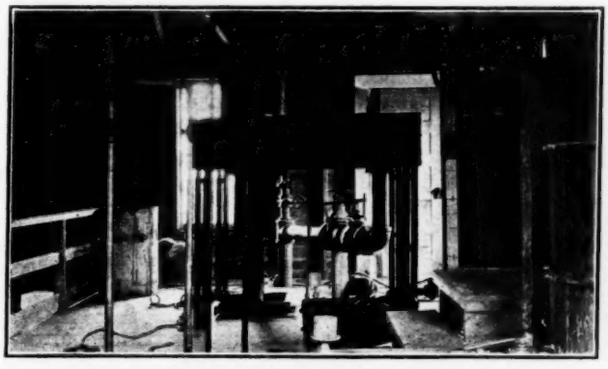
In Jefferson County, Alabama, with an area of over 1,100 square miles, are approximately fifty public and semi-public water supplies, of which thirty-five are of sufficient importance to justify regular supervision of them by the Board of Health. These thirty-five supplies, in which are included the supplies of Birmingham and Bessemer, provide water for more than 325,000 people, or about 85 per cent. of the population of the county. Thus about 40 per cent. of the rural population, and all the urban population, draws water from public or semi-public supplies.

Of the 35 supplies under supervision, 27 are listed as Class A supplies, as they serve more than 200 people; 8 are Class B, serving more than 50 and less than 200. There are also 12 Class C supplies, which classification covers those supplies not considered important enough to justify regular inspections. In addition to this, there are 17 swimming pools, practically all of which employ some of the usual methods of water treatment, and are under some degree of supervision.

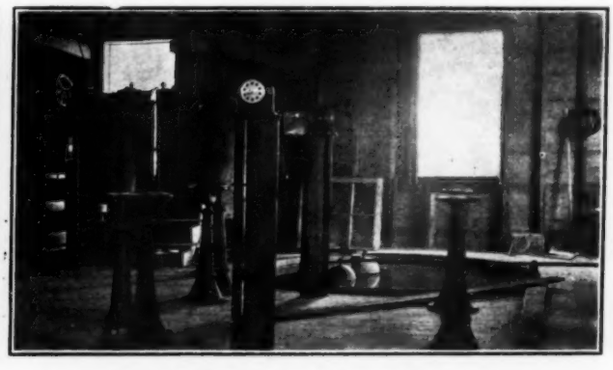
Because Jefferson County is underlaid with a limestone formation, deep wells usually yield a plentiful supply of water. But these supplies nearly always contain excessive amounts of iron, sulphur, or other disagreeable elements, and are frequently of doubtful bacterial quality. Surface waters are almost without exception turbid, are frequently colored from the many coal washers in the county, and are often insufficient in quantity during the summer months. Most surface waters are also of poor bacterial quality and are rather difficult to treat. There are numerous spring supplies, yielding large quantities of water, but most of these are not suitable for use without some form of treatment.

Of the 35 supplies under regular supervision, 10 are from surface sources, 9 from springs, 14 from deep wells, one from an unused mine heading, and one from an abandoned quarry. Of the 10 surface supplies, 6 are filtered and chlorinated, 2 are chlorinated only, and 2 are untreated. Of the 9 spring supplies, 8 are chlorinated. Of the 14 deep well supplies, 1 is chlorinated. The quarry supply is filtered but not chlorinated. Of the total of 35 supplies, some treatment is given to 18.

*Director and Assistant Engineer, respectively, Bureau of Sanitary Engineering, Jefferson County Board of Health, Alabama.



CONTROL APPARATUS, GAMMA PLANT.
Alum tank at extreme right. Soda ash tank just beyond, showing gauge and float tank.



INTERIOR VIEW OF GAMMA PLANT.
Showing one filter, chlorinating tanks at left, loss-of-head gauge and operating valves.

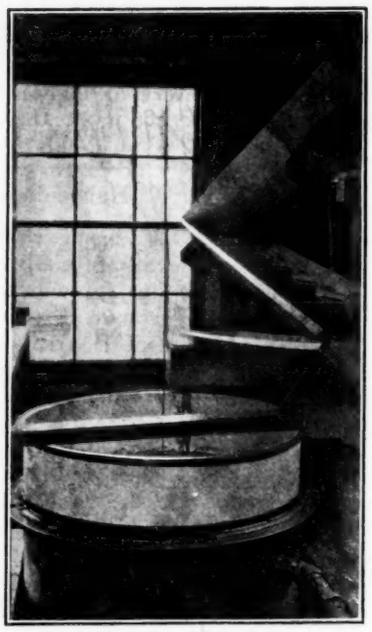
FILTER PLANT BUILDING, LEEDS.
Creek just at rear. Settling basin at right.

The Board of Health, through the Bureau of Sanitary Engineering, inspects and takes samples from these supplies. In doing this, it acts as the agent for the State Board of Health which, by law, is charged with control over all water supplies serving fifty people or more. Communities and corporations owning industrial camps or villages are kept informed of the quality of the water supplied them. Since an outbreak of typhoid in an industrial village about three years ago, in which 17 cases were apparently traced to an infected water supply, with a resulting suit for damages against the company owning the village and furnishing the water, a good deal of interest is shown in these reports and suggestions for improvement are generally followed, if possible.

THE LEEDS PLANT.

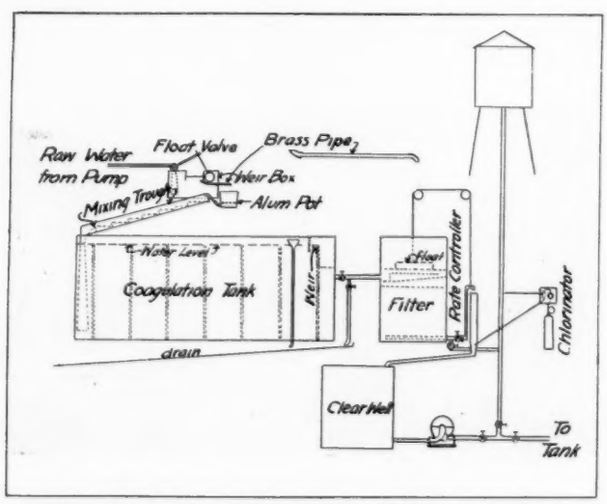
In many cases—in fact in most cases—the corporations realize that a safe water supply is a paying investment. As a result, some very interesting small water treatment plants have been developed to serve some of the isolated communities. The Alabama Power Company has been among the foremost of the large corporations to insist that every permanent station of the company shall have a pure water supply. At the Leeds substation, this company has installed a complete treatment unit, employing coagulation with alum, rapid sand filteration, and disinfection with liquid chlorine, for a community the total population of which is 26. This plant was designed and constructed entirely by the engineering department of the company.

The substation served by this plant is located on the banks of a small stream which during a part of the time is very turbid and at all times is contaminated with the drainage of the town of Leeds, about two miles upstream. As the country is underlaid with limestone, which was known to be fissured and to supply water of a very doubtful quality, it was determined to supply the camp with treated water from the creek rather than to attempt the development of a ground water supply which, in addition to being probably unsatisfactory chemically, would, in all likelihood have to be treated anyway.



MIXING TROUGH AND FILTER, LEEDS.
From mixing trough water flows to coagulation basin outside the building, thence back to filter.

The difficulties of design were increased by the fact that, while a high degree of efficiency was required of the treatment plant, the operation must be so simple that the men normally on duty at the substation could operate and maintain the plant, without undue difficulty and with a minimum of attention.



GENERAL LAYOUT OF FILTER PLANT AT LEEDS
To serve 26 persons. Treatment by coagulation, sedimentation, rapid sand filtration and disinfection.

Water is taken from the creek by a large pump which furnishes water for cooling the transformers, a branch line delivering a comparatively small amount of water to a weir box, from which a uniform gravity flow through the plant is maintained by means of a float valve and a 12-inch weir. As the water passes over the crest of the weir, a small part of the flow is caught by a sharp-lipped funnel and by-passed through a pail containing crystal alum. The resultant saturated solution rejoins the main flow a few inches below the funnel, and is then thoroughly mixed by passage through a 3-section, V-shaped mixing trough, having a total length of flow of about 25 feet. This trough is made by nailing together, to form a V, one 8-inch and one 10-inch board, with small baffles between spaced 12 inches apart, so as to form a series of small cascades.

The water falls from the mixing trough into a baffled wooden sedimentation tank of 3,356 gallons capacity, giving a detention period of slightly over 6 hours.

After passage through the sedimentation tank,

the water flows by gravity into the filter, which is of iron, lined with concrete. The filter is circular, 2 feet 5 inches in diameter, with a surface area of approximately 4.5 square feet, and a capacity, at the rate of 2 gallons per square foot per minute, of 540 gallons an hour. The sand course is 24 inches in depth, and is underlaid with 12 inches of graded gravel, under which is a filter bottom drainage system composed of a cross of ½-inch pipe, slotted by means of hack saw cuts every 3 inches.

One of the most interesting features of the system is the rate controller. The effluent of the filter is brought through a sliding elbow to a

INTAKE OF UNTREATED SURFACE SUPPLY, NEW CASTLE.

movable section of pipe, which is connected by a cord to a float operated by the water on the filter surface. When the loss of head through the filter increases, and the water over the filter rises, the float also rises, thus lowering the discharge pipe, and increasing the available head through the filter.

The filter discharges through this pipe into the clear well. A float operated pump is connected to this clear well. When the water in the clear well reaches a predetermined height, the float operates a switch and the pump starts, raising the water to an elevated tank, which has a capacity of 2,000 gallons.

The effluent from the filter is treated with liquid chlorine by a Wallace & Tiernan MSAM chlorinator. The rate of operation of the chlorinator is so low, that, to avoid difficulty in resetting and readjusting, the chlorinator is allowed to run continuously, the solution being wasted through the drains when the filter is not operating.

The filter is washed by means of filtered water connections to the storage tank. A special valve limits the amount of water that can be used and prevents an excessive rate of washing with consequent damage to the filter. The plant is operated only when conditions are good, and the water fairly clear. Consequently washing is required at quite infrequent intervals.

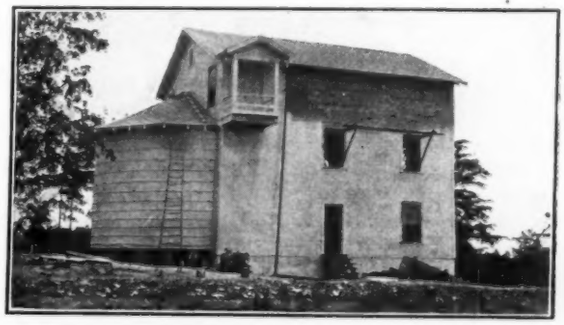
PLANT AT OVERTON, ALA.

Operation is very simple. To start the plant, the chlorinator is changed to discharge into the filter effluent pipe, and the flow of water into the plant is started. To shut off the plant, the operation is reversed. The results of treatment have been very good. There has been no trouble from residual alum, nor from overdosage with chlorine, while bacterial counts have averaged under 10, and with the exception of one set of samples, the filtered and treated water has shown neither gas nor B. Coli. Bacterial counts on creek water vary from 500 to 1,000 per cubic centimeter.

GAMMA PLANT

A larger and more recent plant is that lately constructed by the Alabama By-Products Company to serve the mining camps of Gamma and Wegra, a part of the camp at Praco, and the state mine prison at Wegra, totalling about 2,000 people. This plant, which was constructed by the W. B. Scaife Co., of Pittsburgh, Pa., is of standard type, with wooden tubs for coagulation, sedimentation, and filtration.

A total of about 1,500 gallons a minute is taken from the Warrior river by 8-inch, 3-stage centrifugal pumps and delivered to a storage reservoir about three-quarters of a mile from the river. Most of this water is used for washing coal and for other industrial purposes. That required for domestic use is carried by an 8-inch line from the reservoir to a point near the camp, where it is picked up by two Goulds 4½-inch 3-stage centrifugals direct-connected to Westing-



BUILDING HOUSING THE GAMMA PLANT.
Settling tank at left.

house 40 horsepower motors, and raised to the filter plant. These pumps are rated at 300 gallons per minute each, against a head of 289 feet. All pumping equipment is in duplicate.

The plant, which has no unusual features of design or construction (excepting, perhaps, the unusually long detention period provided in the settling basin), has a normal capacity of 10,500 gallons per hour. The detention period is 6 hours. This rather long period is a necessity with Alabama waters, nearly all of which are turbid to a marked degree. The Warrior river is no exception to this rule, and, in addition to high turbidity, often gives trouble from powdered coal, carried from upstream coal washers. Moreover, the water is of poor bacterial quality, being subjected to sewage contamination a few miles upstream.

The coagulation and sedimentation basin is 15 feet 3 inches deep, and 26 feet 6 inches in diameter, the detention period being 6 hours. As the water enters it is mixed with soda ash and alum and, by means of baffles, carried four times across the sedimentation basin. It then passes to the filters, which are two in number, each 7 feet 5 inches in diameter and 8 feet 4 inches deep. These are of the stave type. The strainer system consists of a 5-inch manifold pipe with 1¼-inch laterals, with ¼-inch brass nipple strainers. Over this are 18 inches of graded gravel and 30 inches of sand. Under normal conditions, a depth of 4 feet of water is maintained on the sand.

Each filter is equipped with a single wash trough located on a diameter of the tub. The troughs are 12 inches wide, 10 inches deep, and the lip is 24 inches above the surface of the sand. Water for washing the filters is drawn from the clear well by a 660-gallon per minute Dayton-Dowd centrifugal pump, driven by a 10-horsepower Westinghouse motor. The clear well, which is located under the filters, has a capacity of about 20,000 gallons.

The chemical feed equipment is of the Scaife auxiliary siphonic type. There are two steel tanks for hypochlorite treatment, a steel tank for soda ash, and a wooden tank for alum. All these tanks are 3 feet in diameter and 4 feet high, and are equipped with constant level float and low water electric alarm. The dosage of chemicals, once the rate of dosage is set, is maintained by means of auxiliary siphons set in action with the main siphon on the raw water inlet. Changes in dosage, for the most part, must be effected by changes in the strength of the solution, though a slight range may be obtained by means of a plug valve.

This plant is an excellent example of the type of plant most suited for small installations in Alabama. The filtered water is without color or turbidity, and after chlorination shows a bacterial count around 50, without gas and B. Coli.

Fig. 1- General Plan of Treatment Plant

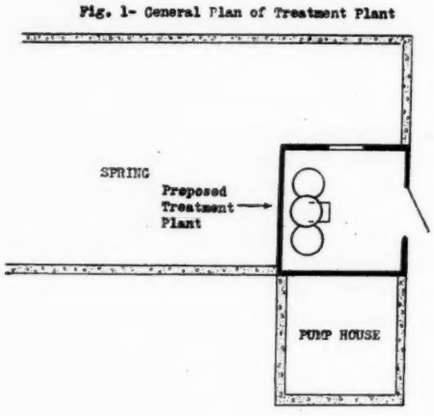


Fig.2- Section of Chlorinator

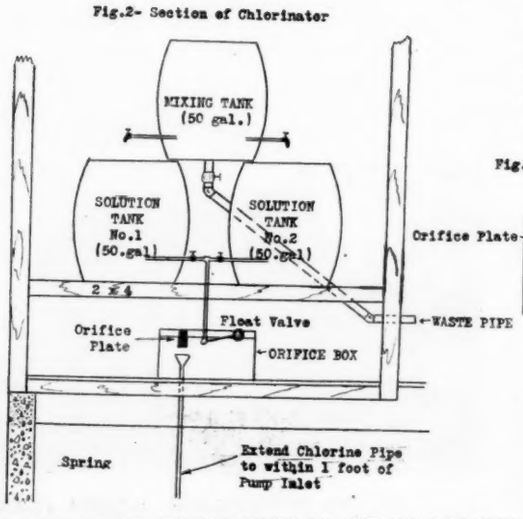
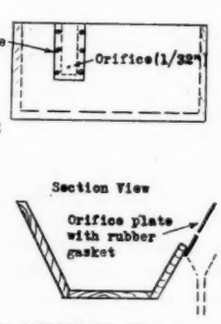


Fig. 3- Detail of Orifice Box



HYPOCHLORITE TREATMENT PLANT OF DOLCITO QUARRY CO

DOLCITO PLANT

The plant of the Dolcito Quarry Company is typical of the very small plants using chlorination alone. This company operates a small industrial camp of about 40 homes a few miles out of Birmingham. Water is obtained from a large spring in the bottom of the quarry. The water from this spring is very attractive in appearance, being crystal clear, and cold, but like most springs in this section shows B. Coli quite consistently. To safeguard this supply, a home-made hypochlorite plant was installed under the supervision of the Board of Health. This is of the familiar barrel type, shown in the accompanying figure. A uniform dosage of chlorine is maintained by means of an orifice kept under a constant head by a float valve.

This type of chlorinating plant is very cheap and is generally quite satisfactory in an industrial camp of this sort, where skilled and intelligent workmen are always available who are responsible for proper operation. Since the installation of this plant, uniformly excellent results have been obtained as shown by examinations of the water.

PUMP AND CHLORINATION HOUSE, IRONDALE RESERVOIR AT RIGHT REAR.

The plants above described are fairly typical of most of those in service. On a number of the supplies Wallace & Tiernan chlorinating equipment is used. On the deep well supplies, filtration is not needed; aeration is used in a few cases, but not generally. Treatment of deep well waters with chlorine is not very feasible because of the large amounts of iron, sulphur, and other dissolved inorganic matter present. One well, used for a time by a mining camp of about 600 population, showed 102 parts of sulphur and 4 parts of iron per million. To treat the average deep well, from 1.2 to 2.0 parts per million of chlorine is required, because the mineral matter present neutralizes the chlorine. To obtain satisfactory bacterial counts, enough chlorine is required so that tastes and odors are produced to which the average industrial worker is very sensitive. As a result, unsafe spring and well waters are used to such an extent as often to nullify the value of treating the main supply.

Purchase of Cement by Highway Dept.

The South Carolina Chapter of the Association of General Contractors of America recently adopted a resolution asserting its opposition to purchase by the state highway department of cement to be used for the construction of roads and other work. The resolution reads as follows:

"Be it resolved by the South Carolina Chapter of the Association of General Contractors of America. That it is opposed to the state highway department buying cement for the construction of its roads and other work for the following reasons:

"1. Because of certain advantages accruing to the contractor through the purchase and control of his materials he is able to effect a saving and this is passed on to the highway department and finally to the public. (Witness to this fact was seen in the recent bids of May 18, the bids being lower where the contractor furnished his materials than when furnished by the department.)

"2. Experience has shown that cement is often purchased below first quotations made.

"3. Contractors are guaranteed the delivery of cement as required for each project, furnishing bonds to this effect and stipulating liability for delay in said bond.

"4. Allowance of prepaid freight on all sacks returned to mills in good condition.

"5. More reasonable terms of payment, 30 to 60 day acceptance being accepted where desired.

"6. Guaranty that cement furnished will meet all requirements of the highway department and that this cement will be tested at least seven days prior to shipment."

North Carolina Highway Research*

Information concerning studies of sand-asphalt pavements, and "planes of weakness," expansion joints and calcium chloride in concrete roads.

By C. M. Upham†

The North Carolina State Highway Commission, being keenly alive to the economic value of highway research in its large construction and maintenance program, has a number of research projects under way, of which the following may be of interest:

North Carolina has for four years been constructing in the coastal regions of the state a type of pavement composed of a mixture of asphalt and local sand. This is known as a sand-asphalt pavement and consists of a bituminous base, composed of from 6 to 9 per cent bitumen and from 91 to 94 per cent sand, and a wearing surface of sheet asphalt. This surface utilizes local sand also, and for this reason a wider range in the screen tests of the sand is allowed than is generally the case in sheet asphalt construction.

North Carolina has been practically alone in the development of this type of pavement and, therefore, a great amount of study and experimentation has been necessary to make this type a success. From year to year, as our knowledge of this type of road increases through study and the building of experimental stations, the specifications are changed to fit our experience.

The problem of regulating or controlling transverse cracks in reinforced and plain concrete roads has been discussed frequently, but no control of the cracks has occurred to date. With this in view, an experiment was tried on one of our state projects in order carefully to study results under normal working conditions. In this experiment our idea was to control or localize the cracks by introducing planes of weakness in the slab during construction. It was decided to introduce these planes of weakness by means of wooden strips at 40-foot intervals throughout a 2000-foot section of a reinforced gravel concrete road. The section selected was on more or less poor subgrade, being part gumbo clay and part loam not very well drained. It was noted at the end of the curing period that at each plane of weakness the slab had cracked and

*From "Highway Research News," the official publication of the Highway Research Board.

†State Highway Engineer of North Carolina; Director, Highway Research Board, National Research Council.

the crack ran through to the subgrade. Another inspection, made seven months later, showed that at all the planes of weakness there were open cracks, and in nearly every instance the crack continued four to six inches out into the shoulder dirt. No other cracks appeared in the 2000-foot experiment section, but were numerous both on tangents and curves on the remainder of the project, which is nine miles long. As this road has gone into its first winter free of cracks other than at the planes of weakness, we feel that a little progress has been made in the right direction. It will be carefully inspected again this spring for further results.

The object of another experiment was to determine the value of expansion joints. The road selected for this work is in very flat country and, due to poor lateral drainage, the moisture content of the subgrade is exceedingly high. The experiment was made by installing ½" bituminous expansion joints spaced 40-foot centers for one mile of road. Immediately adjoining this, one mile of pavement was built without the use of expansion joints. On the next section of two miles in length the expansion joints were placed on 30-foot centers. Thus far practically no cracks have developed in any of the above three sections.

Our method of treating the North Carolina soil roads, such as sand-clay, topsoil, shale, chert, marl, spar, etc., is meeting with a measurable success. This treatment gives results similar in appearance to sheet or sand asphalt. The treatment consists of first applying a prime coat of a specially prepared tar, which, after being covered with sand and opened to traffic for a period, is followed by a top treatment of a specially prepared asphalt, which is also covered with sand. The road is then complete for the first year, but is given careful maintenance. One treatment is applied annually for four or five years. In this way a surface mat is built up to a slab thickness, which furnishes a satisfactory roadway at low cost.

There arises from time to time certain construction work, on which it is highly desirable to shorten the curing period of concrete, so as to inconvenience the traveling public as little as possible. We have in a few instances on such occasions increased the quantity of both calcium chloride and cement in the concrete mixture, which allowed us to open up pavement to traffic after about one-third the usual curing period had elapsed. Cores are taken and observations made on roads in which calcium chloride is used in order to determine the effect of this admixture on the resulting concrete.

English Experiments in Sludge Dewatering*

Experiments are described in which sewage was dried from moisture content of 98% to about 80% by draining for about 20 hours on a sludge bed consisting of land drains, overlaid with granite and topped with sand. The sludges experimented with were of three types —liquid sludge produced by precipitation with lime (4 g.p.g.); plain sedimentation sludge, and limed sedimentation sludge. The prescence of lime, added either prior or subsequent to settling, facilitated dewatering, the plain sedimentation sludge requiring 68 hrs. to drain to 80% moisture, whereas that containing lime required only 20 hrs. The effluent was perfectly bright and clear. Beds prepared with various sands and with ashes as top dressing (3 in.) were compared and it was found that sand with smooth, rounded grains gave the best results, and that removal of sludge cake could be carried out more readily than in case of ashes and sand with rough angular grains. The drying process appears to continue when the cake is removed and tipped on to small heaps, the sludge heating up and emitting large volumes of water vapor when disturbed.

*Abstract, by Bureau of Public Health Service, of paper in the "Surveyor" (England) by Herbert D. Bell, manager and chemist Barnsley Sewage Works.

Equipment for Sewage Treatment Works

What is considered desirable in general, repair, operating, and control equipment. List prepared by committee of New Jersey Sewage Works Association.

Last year a committee was appointed by the New Jersey Sewage Works Association to report on the equipment desirable for sewage treatment works. At the convention of the association this year that committee reported as follows:

The Committee wishes to emphasize the fact that operating equipment is as important as the integral units of the plant. No operator can produce satisfactory results if inadequately supplied with the essential tools to do his work. When a new plant is constructed, the necessary operating equipment should be included with the plant. These items should be renewed and supplemented when necessary. Municipalities are apt to be parsimonious when it comes to supplying their treatment plant with a new hose or rake. The cost of these items is small compared with the difficulties caused the operator when he needs them.

The type of equipment required varies with the type of plant. The following list suggests general groups of equipment. The operator will know what particular items he needs in each group for his plant. Discussion on the matter of operating equipment should be of mutual interest to operators and engineers.

General Equipment

Rubber boots; slickers; garden hose; fire hose; shovels, rakes; lawn mower, snow shovels, etc.; buckets; soap, towels, etc.; brooms, brushes; first aid kit; stationery, report forms.

Repair Equipment

Equipment under this item will run from a few simple tools for the small plant to well equipped machine and repair shops for the large elaborate works.

Pipe fitting tools, with pipe vise, wrenches, stock and dies and a supply of spare pipe and fittings will be of value at most plants. Simple wood working and general tools are also needed.

Sewer cleaning equipment should be owned by every municipality.

This includes rods and cleaning tools and apparatus. A good device seen in Hempstead, L.I., some time ago is a rubber ball that may be inflated to shut off the flow.

Operating Equipment

For Screens

Screening rakes
Cans
Chain blocks or suitable conveying device for handling cans.

For Tanks

Sludge pump, portable, diaphragm force pump type.

Squeegees and scrapers for cleaning baffles.

Sludge sampler. This is an essential item for any plant. A good method is to use an old fashioned handle type well pump with hose suction. This will give a sample at any depth.

A simple and efficient device, worked out by an operator when a pump was not furnished, is to fasten a milk bottle to the end of pipe or pole. A long tapered plug is cut to fit the mouth and a wire fastened to the plug. The plug is pulled when the bottle has been lowered to the desired depth. The contents are little changed when bottle is removed, even when bottle of water is pulled up through thick scum.

For Sludge Beds

Industrial R. R. and cars, or
Wheelbarrows
Trucks
Manure spreader
Forks, rakes.

Control Equipment

This will vary in extent from Imhoff cones and putrescibility outfit to an elaborate laboratory. The operator or technical adviser of the plant requiring more than simple equipment is best qualified to choose the laboratory supplies for his particular plant.

In general it will pay to make such determinations that will give a suitable check on the different processes of the plant.

Meteorological data are of interest at any plant. Air temperatures, wind direction, barometric pressure, humidity, are of value, particularly with reference to odors, if any. Recording thermometers and barometers are convenient and give an authoritative record.

The temperature of the sewage and sludge is well worth recording.

Some means of recording the rate of flow of the sewage is needed, even if only occasional weir readings are taken. Venturi or V-notch meters with graphic, indicating and integrating recorders are fine, but few plants can boast of having them. Where the plant includes a dosing tank, a simple revolution counter attached to a float affords a cheap and effective flow recorder.

Tool House

The ordinary tools used at a plant, as rakes, squeegees, etc., take up considerable room. The appearance of many plants is often spoiled when no suitable space has been provided for these necessary articles and they are allowed to clutter up the pump room, laboratory or whatever space is available.

Adequate storage space should be provided for all necessary equipment and unsightly and dirty tools kept separate from office or room open to visitors.

Connecting Safe and Unsafe Water Supplies

At the conference this year of the State Sanitary Engineers, a committee on cross connections, consisting of H. F. Ferguson, I. W. Mendelsohn, W. J. Scott, E. J. Tully and C. M. Baker, presented a report recommending that certain resolutions be adopted by the conference.

The committee referred to resolutions adopted by the Fire Protection Division of the American Waterworks Association at the 1925 convention of that association and recommended that similar resolutions be adopted by the conference; with certain verbal changes, however, providing for inclusion of auxiliary intakes and by-passes.

These resolutions, after reciting the objections to cross-connections, auxiliary intakes and by-passes, provided that "no physical connections should be permitted between any potable public water supplies, either through cross connections, auxiliary intakes or by-passes, and other supplies except as follows: (1) With another potable public water supply; or (2) With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made." This is to apply to all piping systems, either inside of outside of any building; and definite programs should be inaugurated in each state and each municipality permanently to eliminate all other connections.

A definition was given of what was meant by "cross connection" as follows: "A cross-connection is any physical connection whereby a potable water supply system is connected with another water supply system, whether public or private, in such a manner that a flow of water into the potable supply is possible therefrom, directly through the manipulation of gate valves, because of ineffective check or back pressure valves, or otherwise." It was not intended that cross-connections should include those permitting water from a public supply to discharge into an elevated tank, cistern or suction well at an elevation above its high water line or with a tank

wholly supplied from the public supply and properly protected against contamination. By "auxiliary intake" the committee referred to "any piping connection or device whereby water may be secured from a source other than normally used." By "by-pass" it included "any system of piping or arrangement whereby the water may be diverted around any part or portion of a water purification plant."

The committee sent a questionnaire dealing with the subject to the several state boards of health and received replies from 31. According to these, in ten, all cross connections are prohibited; in six, new ones are prohibited; in seven, there is no definite control, while eight permit them with double check valves as protection.

Replying to the question "Are auxiliary intakes, whereby a polluted supply may be utilized instead of the regular public supply in case of emergency, permitted?", 12 replied that they were prohibited; 12 that they were permitted when protected, as by removing a section of the pipe; five, that they were permitted on condition the state board of health is notified when they are used. In answer to the same inquiry concerning by-passes, 17 stated that these were prohibited; 10 that they were permitted with protection, as by removing a section of the pipe; and two, that there was no definite control.

As to the rules and regulations covering to above, 6 reported definite regulations regarding all three features; 3, definite regulations regarding cross-connections only; 5, general control as a matter of policy without specific regulations; one, regulations for by-passes only; 7 have power to make regulations but have not enacted them; and 9 have no regulations.

In 17 states no trouble has been experienced with the Underwriter's Association in eliminating cross-connections, 4 reported objection by the Underwriter's, and 10 gave no definite information.

Flow Through Culverts

Results of experiments at State University of Iowa on pipe and box culverts show relative carrying capacities of different sizes and kinds of pipe, different treatments of entrance and exit openings, wing walls, etc.

Experiments on the flow of water through culverts have been conducted at the hydraulic laboratory of the State University of Iowa by the university and the Bureau of Public Roads by David L. Yarnell, drainage engineer of the U. S. Dept. of Agriculture, Floyd A. Nagler, associate professor of mechanics and hydraulics of the university, and Sherman M. Woodward, professor of mechanics and hydraulics, and in June of this year a report of the same, edited by Prof. Woodward, was published. "The comparative carrying capacity of culverts under highways is of great importance," says the report, "when the magnitude of the expenditures now being made by both the State and Federal governments for permanent roads is considered."

The investigations were undertaken primarily for the purpose of determining:

1. The quantity of water that will flow through culverts, or sluiceways under levees, of different materials, sizes, and shapes under conditions of actual use.

2. What conditions tend to increase or decrease such quantity.

3. What principles should be followed in design to secure the greatest discharging capacity for the least cost.

Conclusions are drawn from 1,480 experiments on pipe culverts made of concrete, vitrified clay and corrugated metal of diameters ranging from 12 to 30 inches; and 1,821 on concrete box culverts of sizes ranging from 2 ft. by 2 ft. to 4 ft. by 4 ft. and 4 ft. by ½ ft. "Since the highway or drainage engineer is interested principally in the maximum discharge capacity of conduits, only the tests for the pipe culverts flowing full, 1,102 in all, are included in this report."—274 on concrete, 479 on vitrified clay and 349 on corrugated metal; also 1,248 on concrete box culverts. "So far as the writers know, these are the first hydraulic tests ever made on square and rectangular-shaped conduits." Most of the culverts tested were 30 feet long. But to determine the effect of length of culvert, 24-inch culverts 24 and 36 feet long also, of each kind of material, were tested, and also 2 ft. by 2 ft. and 3 ft. by 3 ft. box culverts.

In the discussion the head on the culvert is the difference between the water levels at entrance and outlet (the latter being submerged), which reached a maximum of 3.25. The maximum discharge was 180 cu. ft. per second. The head is used in overcoming resistance to entrance and friction and in producing velocity; the more that goes into producing the last, the greater the quantity carried by the culvert. The entrance loss is affected by the shape of the structure at and near the entrance; the friction loss by the smoothness and uniformity of the walls of the conduit. The shape of the outlet also may affect the amount of head lost.

Within quite a wide range, any size of culvert will carry any amount of water provided there is sufficient head. But creating this head may involve flooding a large area of farm land or even overtopping the road, including softening of the embankment by the water standing against it. In perhaps most cases it is not desirable that the water rise more than one foot above the top of the culvert.

Since the total head available depends on the level of the water below the culvert as well as that above it, there should be ample channel area leading from the culvert.

The amount of the head lost at entrance may be a quarter or even a half of all that available, but can be kept down to 5% by simple precautions. The friction loss may vary from 10 to 75% or more depending upon the smoothness and evenness of surface and the length of the culvert. With a given head, the amount that can be carried by a culvert of a given cross-section will decrease with the length, a 60-foot culvert carrying about 10% to 15% less than a 30-foot.

The concrete pipe used had one end beveled on the inside. When this was set flush with a flat, vertical end wall, the entrance loss was about 5½% of the total head; but if this bevel be filled so as to give a square joint, this loss is increased to 14% to 25%, depending upon the total head. The bell end of a vitrified clay pipe has the same effect, causing an entrance loss of 1% to 7% of the total head; which can be further reduced by filling the bell with mortar and rounding off the edge. Rounding the entrance corner of a 2 ft. by 2 ft. concrete box-culvert 30.6 feet long increased the discharge by about 10%, and a 4 ft. by 3 ft. culvert 13%.

A 45° wingwall does not seem to decrease the entrance loss with a clay or concrete pipe, but has a slightly beneficial effect with a corrugated metal pipe culvert with square end corners. The U-type wings increase the entrance loss in all cases. Standard vitrified clay pipe increasers used at entrances are not so effective as rounding the corner or even as the regular bell end.

Projecting the pipe beyond the end wall increases the entrance loss in all cases; the loss in the case of vitrified or cement pipes is not great but it is considerable with corrugated or other thin metal pipes.

The loss of head due to friction is practically the same for vitrified clay and cement pipe, but is much greater for corrugated because of the turbulence of the water caused by the corrugations. The coefficient N in Kutter's formula varied from about .010 to .013 for concrete and clay but from .019 to 0.23 for corrugated. The percentage of the total head that is lost in friction is in general at least twice as much for corrugated as for the other pipes. With the same head and size, a 30-foot culvert of 12-inch pipe will carry about 70% more if of vitrified clay than if of corrugated pipe, and about 10% more if 48-inch pipe.

(The loss due to friction, however, may be al-

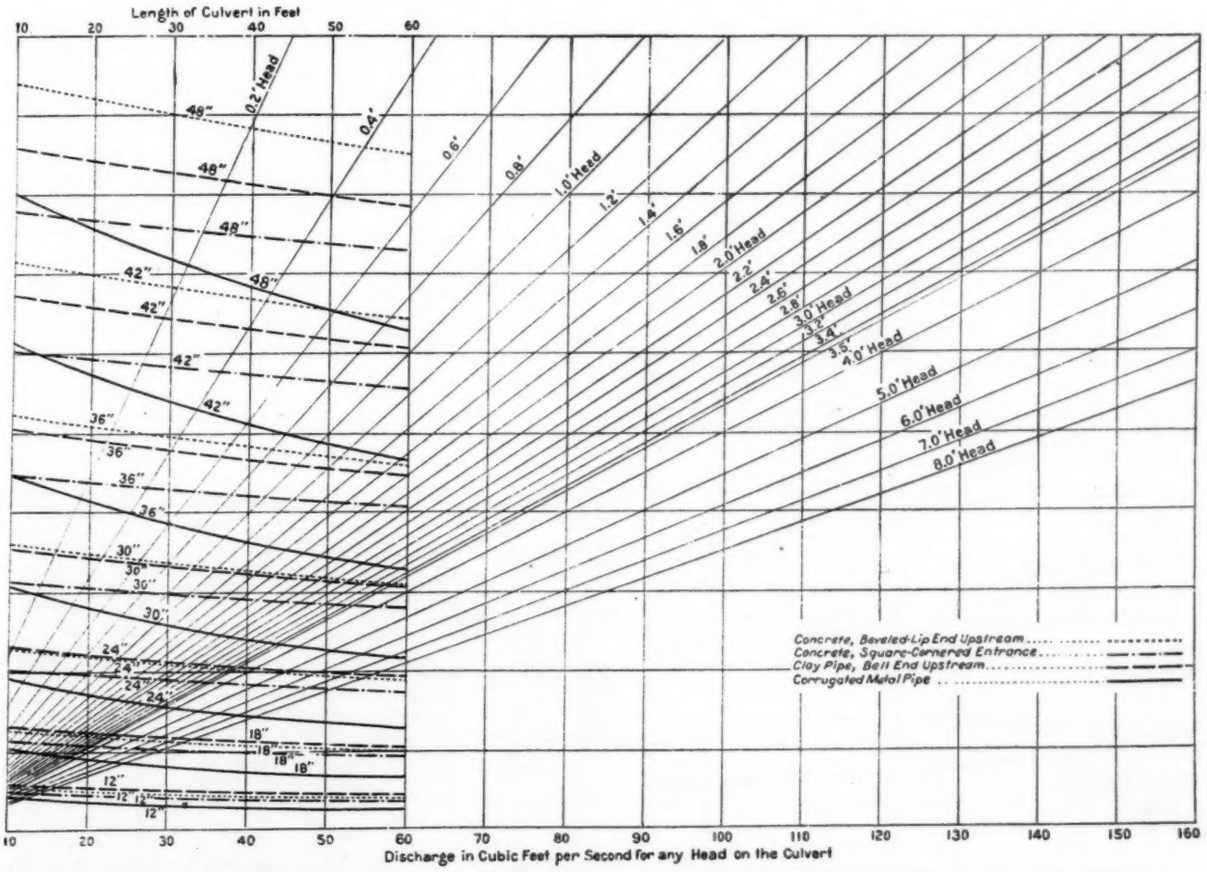


DIAGRAM FOR DETERMINING THE SIZE OF A PIPE CULVERT REQUIRED TO CARRY A KNOWN QUANTITY OF WATER UNDER A GIVEN HEAD FOR LENGTHS 10 TO 66 FEET CULVERTS WITH STRAIGHT ENDWALL ENTRANCES.

Directions for using this diagram. Given: Q, the quantity of water the culvert must carry; H, the safe head the culvert can operate under; and L, the length of the culvert. Find Q on the scale at the bottom of the diagram. From this point run vertically up the diagram to the diagonal line representing H, the safe head to use. From this intersection move horizontally to a point under L, the length of culvert as given by the scale at the top of the chart. The curved line representing a size of culvert nearest to this point gives the required size of culvert.

lowed for by using a slightly larger pipe. Generally speaking, a corrugated pipe with *outside* diameter equal to that of a vitrified clay pipe will have as great or greater a carrying capacity.)

The report gives the relative capacities of pipe culverts 30.6 feet long as follows:

The 12-inch metal pipe has about 67 per cent of the carrying capacity of the 12-inch concrete pipe with beveled lip end upstream.

The 18-inch metal pipe has about 71 per cent of the carrying capacity of the 18-inch concrete pipe with beveled lip end upstream.

The 24-inch metal pipe has about 74 per cent of the carrying capacity of the 24-inch concrete pipe with beveled lip end upstream.

The 30-inch metal pipe has about 76 per cent of the carrying capacity of the 30-inch concrete pipe with beveled lip end upstream.

The 12-inch metal pipe has about 61 per cent of the carrying capacity of the 12-inch clay pipe.

The 18-inch metal pipe has about 68 per cent of the carrying capacity of the 18-inch clay pipe.

The 24-inch metal pipe has about 73 per cent of the carrying capacity of the 24-inch clay pipe.

The 30-inch metal pipe has about 78 per cent of the carrying capacity of the 30-inch clay pipe.

The more important of the other conclusions given are as follows:

Due to the larger amount of pipe friction in corrugated-metal pipes, a change in culvert length produces a greater change in discharge than with concrete and vitrified-clay pipe culverts.

The 45-degree wingwalls used in connection with a corrugated-metal pipe culvert increase the capacity from 1 to 10 per cent over that obtained in a metal pipe culvert with a straight endwall.

The 45-degree wingwalls used in connection with a corrugated-metal pipe culvert are more efficient when set flush with the edge of the pipe than when set 6 inches back from the edge of the pipe.

The 45-degree wingwalls used in connection with a corrugated-metal pipe culvert are more efficient when built full height to the top of the headwall than when constructed only to the standard height.

The 45-degree wingwalls used in connection with a vitrified-clay pipe culvert produce a carrying capacity substantially equal to that with the regular bell end upstream.

A 24-inch clay pipe, 38 feet long, with a straight endwall and the regular bell-end upstream carries about 10 per cent more water than the same culvert with a square cornered entrance.

Merely rounding the entrance to a 24-inch vitrified-clay pipe culvert increases the capacity approximately 13 per cent over that obtained with a square cornered entrance.

By doubling the area of the outlet end of an 18-inch vitrified-clay pipe culvert by attaching a conical section, the sides of which diverge at an angle of about 10 degrees, the discharge of the culvert, when the outlet end is submerged, is increased about 40 per cent over that obtained through the same culvert having a uniform bore throughout.

Concrete box culverts with straight headwalls and rounded lip entrance discharge from 8 to 12 per cent more water than the same size culvert with square cornered entrance in the sizes tested in this investigation.

Concrete box culverts with straight headwalls and beveled lip entrance discharge from 7 to 9 per cent more water than the same size culvert with square cornered entrance in the sizes tested in this investigation.

If the outlet end of a 36-foot box culvert with a rounded lip entrance is flared by diverging the sides at an angle of 6° 30′ throughout a distance of 10 to 12 feet from the outlet headwall, thus doubling the area of its cross-section at the outlet, the capacity of the culvert is increased

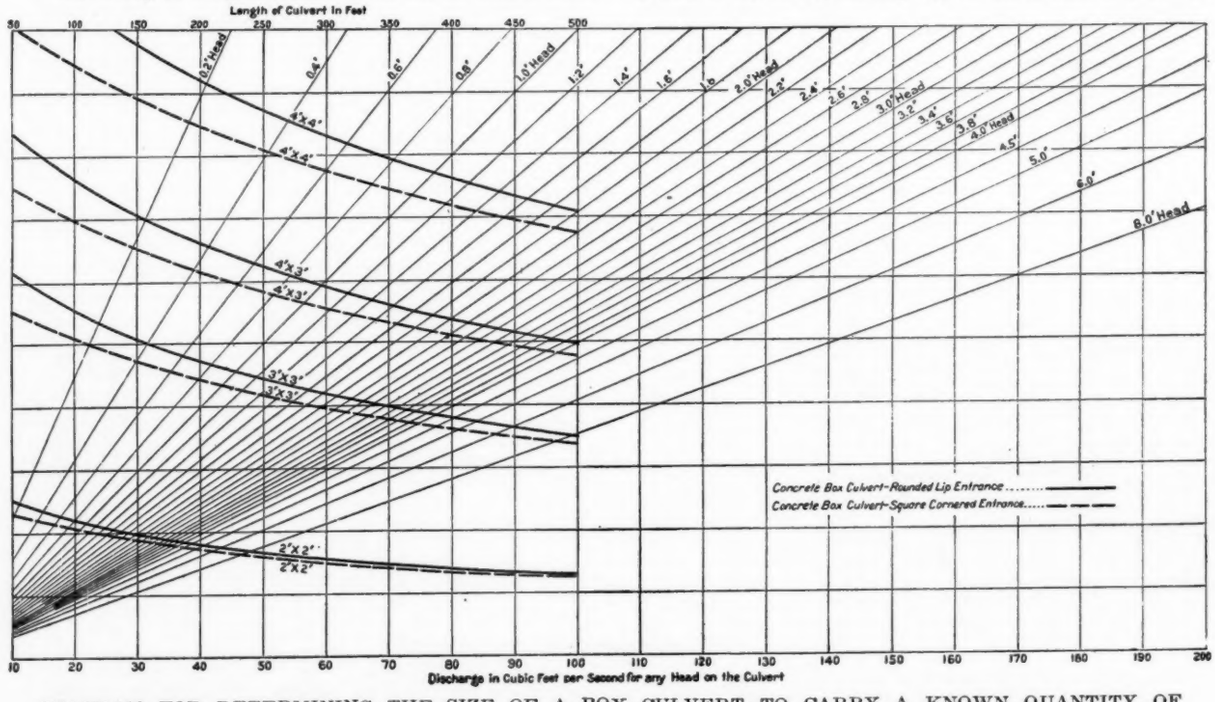


DIAGRAM FOR DETERMINING THE SIZE OF A BOX CULVERT TO CARRY A KNOWN QUANTITY OF WATER UNDER A GIVEN HEAD FOR LENGTHS 50 TO 500 FEET. CULVERTS WITH STRAIGHT END-WALL ENTRANCES.

Directions for using this diagram. Given: Q, the quantity of water the culvert must carry; H, the safe head the culvert can operate under; and L, the length of the culvert. Find Q on the scale at the bottom of the diagram. From this point run vertically up the diagram to the diagonal line representing H, the safe head to use. From this intersection move horizontally to a point under L, the length of the culvert as given by the scale at the top of the chart. The curved line representing a size of culvert nearest to this point gives the required size of culvert.

about 60 per cent above the capacity of a similar culvert 36 feet long with the uniform bore extending the entire length of the culvert.

The 2-ft. by 2-ft. box culvert, 30 feet long, with a rounded lip entrance and flared on the two sides for its entire length to a 4-ft. by 2-ft. opening at the outlet end will discharge 86 per cent more water than a 2-ft. by 2-ft. by 30-ft. box culvert of uniform bore with a square cornered entrance, when both culverts are flowing full.

The 2-ft. by 2-ft. box culvert, 30 feet long, with a rounded lip entrance and flared on the two sides for its entire length to a 4-ft. by 2-ft. opening at the outlet end will discharge the same quantity of water as a 3.61-ft. by 2-ft. by 30-ft. box culvert of uniform bore with a square cornered entrance, when both culverts are flowing full.

Rectangular concrete box culverts require more head to overcome friction than square concrete box culverts of the same area, and hence have a smaller carrying capacity provided the entrance losses (in head) are the same. The head lost in friction for culverts of the same area varies inversely with the hydraulic radius. The entrance losses, however, on the rectangular culverts tested are less than those on the square culverts of the same area and type of entrance. Since one culvert differs from another in capacity per square foot of area inversely in proportion to the square root of the sum of all head losses involved, it is possible for a rectangular culvert to have a slightly greater capacity than a square culvert, although the reverse is usually the case.

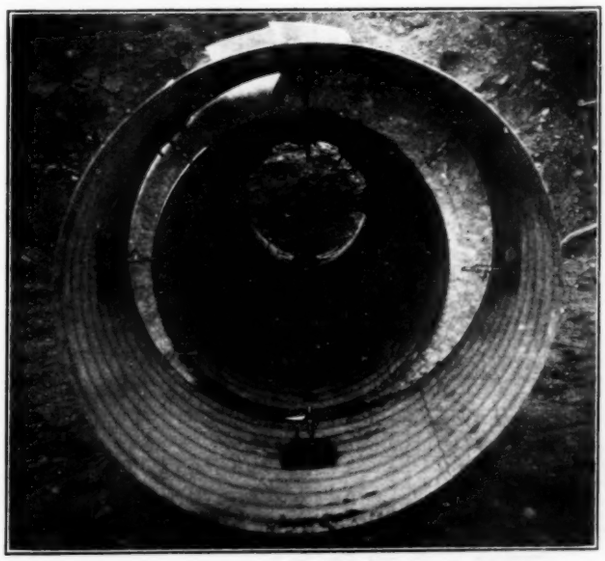
The chamfering of the corners of box culverts reduces the discharge of the culvert by an insignificant amount, an amount which is less in per cent than the corresponding reduction in culvert area produced by the chamfering.

A comparison of the results of the tests on the concrete box culverts with the results of the tests on the pipe culverts reveals the following facts:

A 24-inch concrete pipe culvert, 30 feet long, with beveled lip end up stream, carries 19 per cent less water than a 2-ft by 2-ft. by 30-ft. concrete box culvert with square cornered entrance (when the two culverts are flowing full), but the concrete pipe culvert carries about 7 per cent more water per square foot of waterway than the box culvert.

A 24-inch corrugated-metal pipe culvert, 30 feet long, carries 57 per cent less water than a 2-ft. by 2-ft. by 30-ft. box culvert with square cornered entrance (when the two culverts are flowing full), and the metal pipe carries about 23 per cent less water per square foot of waterway than the box culvert.

A 27-inch vitrified-clay pipe culvert, 30 feet long (containing approximately the same cross-sectional area as a 2-ft. by 2-ft. box culvert) will carry 7 per cent more water than the 2-ft. by 2-ft. by 30-ft. box culvert with square cornered entrance, when both culverts are flowing full.



CORRUGATED METAL CULVERTS, SHOWING METHOD OF MOUNTING CELLS.

Effect of Loads on Culverts

Experiments on 24 to 48-inch pipe culverts under actual embankments up to 38 feet height, with measurements of pressures at various parts of the circumference. Deflection of flexible pipe produces uniform pressures at all points.

The Roadway Committee of the American Railway Engineering Association has, for several years past, been investigating the strength, durability and economy of different types of culverts and since, to a considerable extent, the conditions and uses of culverts under railroads are similar to those under highways, the reports of the committee will undoubtedly be of interest to highway engineers and superintendents. The report submitted this year, based upon investigations made in 1925, is devoted almost exclusively to a consideration of the loads carried by culverts and the deflections resulting in corrugated metal culverts.

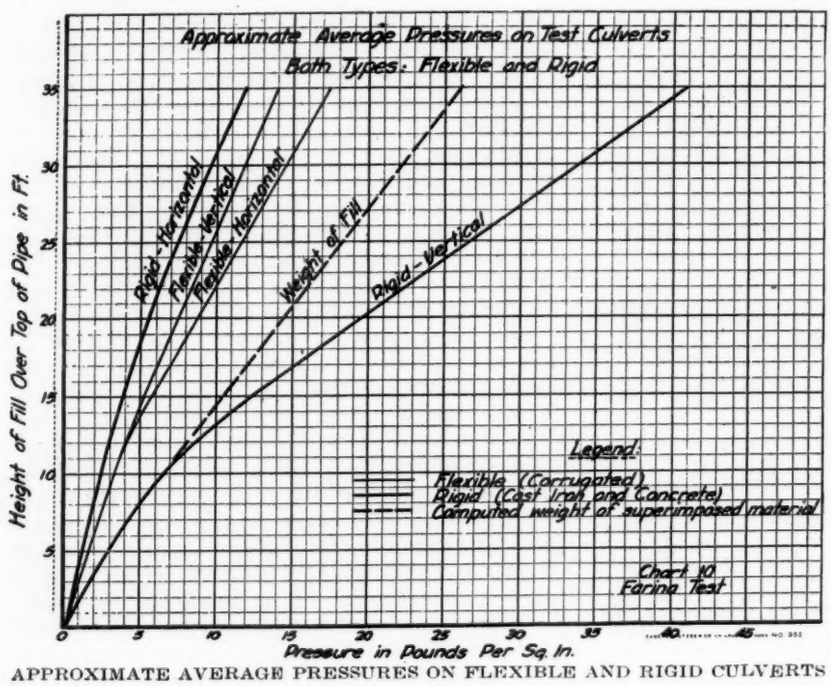
Concerning durability, the committee says that it has received reports on several thousand culverts, most of which are in excellent condition, while little can be learned concerning those which have failed except that in some cases the cause was careless installation. Inquiry concerning this and concerning economy, which depends largely upon durability, is being continued.

While tests of culvert pipe of the kind known as two-point and three-point tests seem to be fairly satisfactory for concrete, vitrified clay and other rigid types, this test is of little value in connection with corrugated iron or other flexible types. In 1908 Prof. A. N. Talbot tested pipe enirely surrounded by and covered with sand; and, in 1916 George L. Fowler made tests in much the same way; while in 1923 at the National Railway Appliances Exposition, the Armco Culvert & Flume Mfrs. Assn. demonstrated a similar apparatus. In all of these tests the sides of the box were held rigidly in place and it is probable that for this reason the pipe developed more strength than it would possess under an embankment.

The committee decided to make tests in an actual fill and to obtain more varied and complete data than had been obtained in previous tests. Two preliminary tests were made with a view to developing the details of procedure, and these having apparently demonstrated the feasibility and satisfactoriness of the plan, a complete set of tests were conducted at Farina, Illinois, where the pipes were buried in an embankment of the Illinois Central Railroad which was about 38 feet high and over which trains were not yet running.

In the first preliminary test a 24″ 10-gage corrugated and a 24″ reinforced concrete pipe were used, the latter being the standard for

Kentucky State Highways. These were covered with three feet of earth and pressure applied through a cast iron plate 2 ft. wide and 7½ ft. long by means of two 6 in. rams which had a capacity of 100 tons each. Under 100 tons the corrugated pipe deflected a total of 2⅜" vertically and widened 2" horizontally. The concrete pipe developed a crack when 24 tons (2.67 tons per linear foot) had been applied, after which the crown settled an increasing amount at each increment of load until at 70 tons the pipe was completely wrecked.

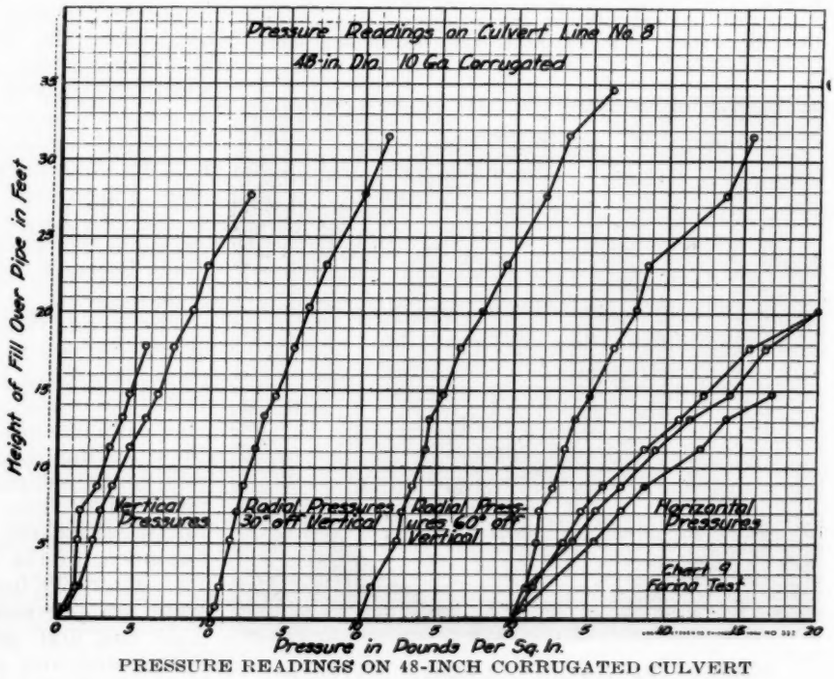


APPROXIMATE AVERAGE PRESSURES ON FLEXIBLE AND RIGID CULVERTS

The committee referred to the discussion of culvert loading by Prof. Talbot published in Bulletin No. 22 of the University of Illinois, in which he showed that for a load uniformly distributed both vertically and horizontally the bending moment of a thin elastic ring is represented by the equation $M = 1/16\ (1 - q)\ WD$, where W is the total load per unit of length of pipe, D is the diameter, and q is the ratio of the horizontal to the vertical load. One object of these tests was to determine the value of q for culverts of flexible material.

In order to measure the pressures the committee used the Goldbeck cell devised by A. T. Goldbeck while connected with the U. S. Bureau of Public Roads and referred to several times in articles in Public Works. This apparatus, which has been used by the Bureau of Public Roads frequently during the past few years, records the air pressure required to balance the external pressure on the diaphragm of the cell. At the instant when the air pressure produces a slight movement of the diaphragm (said to be as slight as .0001 inch), an electric circuit is broken. This causes the small signal light in front of the large dial to flicker or go out, the gage pressure being noted at that instant. The dial is calibrated to show in pounds per square inch the external pressure on the diaphragm.

These diaphragms were inserted in the corrugated pipe through holes cut in the pipe wall, the diaphragm being set just flush with the ridges of the corrugations on the outside of the pipe and bolted in position. They were set at regular intervals in the top of the pipe, while at a number of points another diaphragm was set at the bottom and one at each end of the horizontal diameter; and at one point in the cast iron pipe of the Farina test additional diaphragms were set 45 degrees from the vertical in the lower half and both 30 and 60 degrees from the vertical in the upper half. In the Farina test eight lines of test culverts were employed.


Pressure Readings on Culvert Line No. 8
48-in. Dia. 10 Ga. Corrugated
Height of Fill Over Pipe in Feet
Pressure in Pounds Per Sq. In.
Vertical Pressures
Radial Pressures 30° off Vertical
Radial Pressures 60° off Vertical
Horizontal Pressures
Chart 9
Farina Test

PRESSURE READINGS ON 48-INCH CORRUGATED CULVERT

four of 42″ 12-gage corrugated pipe, one filled 6 ft. over the pipe, another 12.2 ft., a third 33.5 ft. and the fourth 34.9 ft. There was one line of 24″ 14-gage corrugated with 33.1 ft. cover and another of 48″ 10-gage corrugated with 34.6 ft. cover. There was also a 24″x27″ concrete culvert of the standard construction of the Illinois Central Railroad with 32.2 ft cover and a 42″ extra heavy cast-iron culvert with 34.2 ft. cover.

Extreme care was taken to see that all culverts were installed under exactly similar conditions. The embankment was tamped by hand to three-fourths the height of the pipes and at least 14 in. out from the sides. The deflections of the top cell were read with an inside micrometer reading inches to three decimal places. The filling for the first 8 ft. consisted of a very loose grained top soil which was dry and could not be tamped very much, above which was placed a dense, compact yellow clay which packed readily. The top soil weighed 85 lbs. per cubic foot and the clay averaged 112 lbs. The fill was placed in layers two feet thick and elevations were taken over each culvert and the pressures and deflections read after each layer had been placed and leveled off.

The committee says:—"Considering the amount of the projection of the pipes above the natural soil and the weight of the filling material, it seems probable there will seldom be installations where the culvert will be subjected to more severe loading. For this reason the deflections shown may be taken as somewhat greater than may be expected under ordinary conditions."

Comparing the 24″ concrete and the 24″ corrugated, the concrete pipe fractured longitudinally throughout its length before the entire fill of 32 ft. had been completed but without any marked deflection. The corrugated pipe deflected about 0.8 inch at the completion of the 33.1 ft. fill.

Comparing 42″ corrugated with the 42″ cast iron, the maximum deflection of the former was 3.062″ and of the latter 0.262″, both remaining intact. The 48″ corrugated culvert showed a total deflection of 4.94″ with a total fill of 34.6 ft.

Comparing the pressures on the 24″ corrugated pipe and the 24″ concrete pipe, it was found that in the case of the corrugated pipe the side pressures fairly approximated the top pressures, while in the case of the concrete pipe the side pressures were approximately only 30% of the top pressures. Also the top pressures on the corrugated culvert were only about 39% of the top pressures on the concrete, while the side pressures on the corrugated were about 145% of those on the concrete. "Attention is drawn to the characteristic manner in which the rigid type supports the major portion of the load on its crown and the characteristic manner in which the flexible type distributes the load over its circumference."

One of the accompanying charts shows the pressures on the 30 and 60 degree radii, as well as the vertical and horizontal, showing how uniform these pressures were. It will be seen that, for each loading up to 20 ft. fill, the average of these four pressures is practically the same as the average of the vertical and horizontal pressures on the rigid type. The other chart shows the approximate average of the vertical and horizontal pressures for both rigid and flexible types. "For comparative purposes there has been inserted a curve showing the approximate weight of a column of earth 1 inch square directly above the crown of the pipes. This curve was computed from the actual weight of the material which made up the fill. It will be noted that the vertical and horizontal pressures of the flexible type closely approximate each other, whereas, in the case of the rigid type, there is a considerable variation; at the 35 ft. level the horizontal pressure being only about 30% of the vertical pressure. Now, considering the weight of the superimposed material, it will be noted that the vertical pressure on the flexible culvert is always less than the weight of the column above it, while the vertical pressure of the rigid type culvert is always more for heights above 10.5 ft. At the 35 ft. level the vertical pressure of the flexible type is 54% of the weight of the column of earth directly above. The vertical pressure of the rigid type at the same level is 158% of the weight of the column of earth directly above."

As the concrete was the only pipe to fail, no definite conclusion can be drawn as to failure point for the others, but further experiments will be made to determine the safe deflection and failure points of corrugated metal culverts under various embankment loading conditions. The report concludes with the following Summary and Acknowledgments:

SUMMARY

Results so far show that under the conditions of the Farina Test:

(1) The intensity of vertical pressure measured by the top cells on the corrugated culverts is about one-third of the measured vertical pressure on the rigid type of culvert under the same condition of loading.

(2) The intensity of vertical pressure measured by the top cells of the corrugated culverts is about 54 per cent of the weight of the unit columns of the material above the cells.

(3) The intensity of vertical pressure measured by the top cells of the rigid culverts is about 158 per cent of the weight of the unit columns of the material above the cells.

4. The intensity of pressure at the horizontal axis of the corrugated culvert is equal to or greater than the intensity of pressure at the vertical axis.

(5) The intensity of pressure at the horizontal axis of the rigid culvert is about one-third of the intensity of pressure at the vertical axis.

Observations are being continued at intervals of about 90 days. It is the intention to continue this for an indefinite period in order to determine what changes, if any, take place as the fill consolidates under traffic.

Records of readings on lines numbers one and two are being held until after the line is under traffic, when the Committee expects to make determination of the live loads transmitted for those fill heights.

A report on this work will be available for next year.

ACKNOWLEDGMENTS

The Committee is indebted to the Armco Culvert and Flume Manufacturers' Association for the financing of the tests. It is desired to express appreciation of the co-operation by the Illinois Central Railroad in furnishing the

site for the test as well as actual engineering assistance. The Committee is also indebted to Prof A. N. Talbot, who, with his staff, has offered much constructive and valuable co-operation. Messrs. Goldbeck and Smith, of the U. S. Bureau of Public Roads, have given valuable guidance in the use of the soil pressure cells and in the actual planning of the tests.

Materials Used for Highway Culverts

In the questionnaire that we sent this Spring to county highway engineers was an inquiry as to what materials other than concrete they used for culverts, it being assumed that in most sections of the country rectangular culverts or those of any shape built in place are constructed of concrete. About 300 replies to this question were received, some of the counties reporting the use of two kinds of material and a few of them of three kinds.

By far the largest number reported using corrugated metal pipe, these amounting to 63.3% of the whole. Vitrified pipe came next with 12.9%; followed by cast iron with 7.1%, concrete pipe with 5.5% and wood 2.7%. Concrete alone was reported by the remaining 8.5%.

The above figures are for the country as a whole. The comparative popularity of the various materials varied, however, in different sections. On the Atlantic Coast about 44% reported corrugated, 8% vitrified, 21% cast iron, 13% concrete pipe and 2½% wooden culverts. In the East North Central States corrugated was reported by 50½%, vitrified by 29%, cast iron by 10%, concrete pipe by 2% and wood by 1%. In the East South Central one-third reported the use of corrugated, one-third of cast iron and the remaining third nothing except concrete. In the West North Central 74% reported using corrugated, 5½% vitrified, 3% cast iron, 7% concrete pipe and 2% wood. In the West South Central 67% used corrugated, 11% concrete pipe and 5½% wood. In the Mountain district 82% used corrugated and 14% wood. In the Pacific States 88% used corrugated, 6% concrete pipe and 6% wood. In each case the remainder of the 100% reported the use of no material except concrete culverts.

In the above it will be noticed that corrugated metal is especially popular in the states west of the Mississippi; vitrified pipe was reported only from the South Atlantic, East North Central and West North Central states; cast iron is used only east of the Mississippi and in the West North Central states; concrete pipe finds its most general use in the Southern states, although a number of those in the West North Central District make use of it; and wood is most popular in the Mountain States but is found to a greater or less extent in all of them except possibly the North Atlantic and the East South Central.

Trunk Sewer for Westchester County

The Westchester County Sanitary Sewer Commission announced on July 29th details of a new trunk sewer to be known as the Hutchinson Valley sewer, which will serve parts of New Rochelle, Pelham, Mt. Vernon, Eastchester and Yonkers. It will be designed of capacity to serve 54,000 persons and it is estimated that in fifty years the population in the district will have increased to 159,000. This sewer will be about seven miles long. It is hoped to have it completed by the beginning of 1928.

Water Purification Devices in Ohio*

Recent practice of Ohio plants in installing and operating coagulant feed devices —mixing devices—clarifiers—equipment for generating and applying carbon dioxide.

By F. H. Waring†

COAGULANT FEED DEVICES

Up until a few years ago coagulant was applied at practically all plants by means of solution feed tanks and orifice devices. With one or two exceptions all of the last 10 or 12 plants constructed in this state have utilized dry feed apparatus for applying the chemicals. Reluctance in changing from the solution feed to the dry feed system was observed at first due to mechanical difficulties encountered in the earliest types of machines; these difficulties have been largely eradicated.

For application of the coagulants it was common practice five or ten years ago to provide metal piping of special character, these pipes being imbedded in the concrete of the filter plant structure. Clogging troubles have demonstrated that it is advisable to place piping in accessible locations, and provide for short travel of the chemical from the machine to the point of application. At all of the recently constructed plants flexible hose of rubber or composition material has been employed, and experience indicates that clogging troubles are now practically nil. These hose pipes are placed in the open and the most direct route from the chemical machine to the water receiving the chemical is taken.

MIXING DEVICES

Early design employed gravity baffled mixing chambers with either horizontal or vertical flow of the water and long periods of retention, many of the plants having as much as one hour in the mixing chamber. None of the new plants installed in the last two or three years in Ohio use this type of mixing. One style of gravity mix, however, is now employed, namely, the hydraulic jump. The new Baldwin filtration plant at Cleveland uses this device, which was developed by J. W. Ellms, engineer in charge of water purification at Cleveland. This style of mixing chamber utilizes velocity head for a very efficient mingling of the chemicals with the water. With the exception of the Cleveland plant, all other new plants in this state are utilizing some variety of a mechanical mixing chamber. The incentive for this style was largely the experimental work done in connection with the design of the

*Second part of a paper before the American Water Works Association entitled "New Features of Water Purification Practice in Ohio." The first part was published in the August issue.

†Chief engineer, Ohio State Board of Health.

Sacramento filtration plant and corroborated by laboratory experiments of C. P. Hoover and others in this state.

Two general types are used, the vertical hanging blades or agitators, and the horizontal suspended blades. Generally two tanks are provided to give flexibility, each with individually operated single-shaft agitators. At first more than one agitator shaft was employed in a tank, but experience indicates that undesirable velocities are set up which break the floc formed.

The tendency to use the mechanical mix is accounted for by some of the advantages obtained, as follows: The system does not utilize extra head through the device; ease of construction makes it possible to enclose the entire mixing chambers within the chemical house; likewise chemical feed equipment may be placed immediately adjacent, with direct application of the chemicals through short lines; in most instances less than two horsepower is required for operating each agitator; a definite velocity may be obtained irrespective of the changes in flow of raw water through the plant; and the velocity may be adjusted at will by varying the speed of the motor driven mechanism. Generally speaking, these tanks are designed to hold about 20 minutes retention and the speed of the agitator is set to give the water a velocity of about one foot per second.

CLARIFIERS

Municipal water treatment practice has copied from industry another device, the clarifier, which has been developed largely by the Dorr Company. There are three in service in Ohio, all three of them in connection with water softening installations. The character and volume of the precipitate resulting from the raw water treatment determines to a large extent the advisability of installing thickening devices of this nature. For the most part turbidities are not encountered in Ohio that would warrant the installation of clarifiers in ordinary water treatment practice. The three softening plants employing Dorr clarifiers are Newark, Greenville, and Piqua. The first installation was circular in style, but the two recent ones are square. The water is retained about one hour and permitted to flow through the clarifier at a low velocity of travel somewhat less than one-half foot per minute. The mechanically operated thickener is set for a slow rate of travel, usually about four revolutions per hour.

The advantages of the clarifier, particularly for water softening practice, are seen from the results cited for the Newark plant. The clarifier removes about 98% of the total suspended matter present in the water leaving the mixing chambers. Another advantage is that sludge removal may be conducted continuously and in less objectionable manner. This item is of particular importance where a small stream must receive the discharge of the sludge and waste water from the purification works.

A striking inference may be drawn from the performance of the clarifier in the softening practice, namely, the great reduction in size of settling basins neded prior to filtration. At the Newark plant installed two years ago, regular practice was followed and settling basins holding 8 hours of supply were constructed. Based upon the performance of this plant the Greenville and Piqua designs have reduced the settling basins capacity to retentions of from two to three hours. In the latter design a by-pass of the settling basins has been arranged in order to determine whether or not all of the settling basin may be omitted.

CARBON DIOXIDE APPLICATION EQUIPMENT

Carbon dioxide gas is employed in water treatment at several plants in this state; for the most part this treatment is used at softening plants for the prevention of after-precipitation of mono-carbonates. There are two general features of carbon dioxide application; the generation equipment and the absorption chambers.

Research work is still going on with regard to the best method of generating carbon dioxide for water treatment practice. In Ohio four plants are using coke for fuel, one uses oil, one uses powdered coal, and one contemplated will use producer gas. Based upon the experiences thus far it would seem that burning of coke affords the best way of obtaining carbon dioxide for the medium size and small plants. For very large installations it appears now that the burning of producer gas will be the best. It is this type of installation that the city of Columbus is going forward with. The producer gas will be manufactured first by burning coke with a restricted air supply for draft and the resultant gas then burned under the boilers, in order to utilize the heat of burning of the producer gas. The chimney gases from this boiler will then carry a very high percentage of carbon dioxide and be quite serviceable for carbonating the large volumes of water at this plant. It seems desirable to include with the generating equipment a scrubber and drier to take out impurities from the gas that might affect the compressor. Experience at two plants has shown that the compressor is affected if insufficient scrubbing of the gas is done before compressing. However, one new plant (Girard) is employing a new type of compressor that is water lubricated, which promises to make possible the omission of scrubber and drier as a preliminary to compressing the gas.

At the first plant to install carbon dioxide equipment (Defiance) special provisions were made to cause the gas to be absorbed by the water. A carbonation chamber was arranged that had filtros diffusers to break up the gas in small bubbles; also baffled compartments to cause the water to travel downward against the upward flow of bubbles; and drainage facilities to take away possible precipitates that might be formed. Experience has shown that the precautions cited are not needed to obtain satisfactory carbonation. The recent plants are employing the last portion of the settling basin, say a capacity of 30 minutes retention, instead of providing separate basins. No particular baffling is done except to partition off this compartment from the remainder of the basin and thus prevent the disturbing of the suspended matter already settled out in the basins. For distributing gas, ordinary grids of piping with small perforations, say from 1/16 to 1/8 inch, are giving good satisfaction. Tests with such piping show 90% of the carbon dioxide applied is absorbed, even when the depth of the water is not greater than 8 or 10 feet.

New Hampshire and Vermont Begin Traffic Surveys

Highway transportation surveys covering the entire states of New Hampshire and Vermont were begun last month under cooperative agreements between the U. S. Bureau of Public Roads and the two state highway departments.

In general, the same methods will be used as in the Connecticut and Cook County surveys, reports of which have been published, and the Pennsylvania and Ohio surveys which are now being analyzed. For passenger vehicles the data will show the number of vehicles passing the station during each hour, the state in which they are licensed, the number of passengers they carry, whether the purpose of travel is business or pleasure, whether the passengers are from city or farm, whether the travel is an extended tour or a short trip, the origin, destination, length of trip and the number of miles of travel within the state.

For trucks the data will show also the number passing each hour, the state of registration, capacity, origin, and destination, with information as to the character of operation and of the consignor and consignee, the total distance of travel and mileage within the state, the commodity transported, the type of trucking (for hire, contract hauling, etc.), and the situs of ownership. In addition to this information there will be recorded at special weight stations, the make of truck, type of tires, and weights on front and rear axles.

Analysis of this information will make it possible to prepare maps showing the present volume and distribution of passenger vehicle and truck traffic on the highways of each of the states, from which the state highways will be classified as industrial, high, medium, or low-type routes, taking into account motor-truck capacities and loads. A forecast of traffic for several years ahead will be made and a definite program of highway construction worked out. Special attention is to be given to an analysis of the relative traffic importance of the township roads with respect to the primary and secondary systems.

Economic data to be collected will include information concerning the tonnage shipped by motor truck, marketing methods, zones of truck operation, and general trucking practice.

New York's Rubbish

The ashes and half the rubbish from Manhattan Borough, New York, are delivered to waterfront dumps whence they are removed by scows. The balance of the rubbish goes to two incinerators. In Brooklyn, ashes and much of the rubbish are taken by scow or railway to Flushing meadows for fill, the two incinerators in that borough handling the remaining rubbish—160 tons per day. In The Bronx, disposition is at land dumps, where the rubbish is burned, or by scow to Rikers Island

Dirt Road Maintenance

Supplementing table published in the May issue and containing information furnished by questionnaires received since it was compiled. Kind, width and crown of road, equipment used and frequency of treatment.

County	Kind of soil	Average width of graded sections, feet	Average crown, inches	Mileage kept in condition	Equipment used in keeping surface even	Frequency of treating a given stretch of road	Percentage of time road has a firm, smooth surface	Other treatment received by earth roads
Arizona:								
Gila	Clay, solid rock	20	5	413	Drags, blades	12 permanent maintenance gangs	100	....
Greenlee	Sandy clay	18	4	50	Drags, graders	Weekly	50	....
Pinal	Decomposed granite dlabase, clay	20	3	626.3	Drags, graders, planers	Generally only after rains	50	....
California:								
Stanislaus	Gumbo, sandy clay, sand	30	..	1,300	Drags	Every 2 weeks in wet season	..	None
Colorado:								
Baca	Sandy clay	26	..	550	Drags, blade graders	After rain or snow	95	Clean ditches, crown road
Delaware:								
Kent	Clay, sand, sandy clay, loam	24	8	1,000	Drags, one-man graders	Main roads after each rain	9 months	None
Florida:								
Manatee	Sandy clay	24	4.8	100 to 150	Blades, drags, rollers	Once a month	50	Drainage
Saint Lucie	Clay and sand	24	..	..	Graders, drags	Every two months	35	....
Idaho:								
Boise	All kinds	18	..	160	Drags, scrapers	Semi-monthly	85	....
Elmore	Granite, sand	8	..	..	....	....	..	....

Illinois:								
Iroquois	Clay, sand, sandy loam	..	..	..	Graders, tractor drags, horse drags	....	..	Road oil
Marion	Clay	20	..	..	Drags	Once a month	80	....
Schuyler	Clay, gumbo	30	15	600	Drags, scrapers, blades	Once or twice a week	80	....
Shelby	Clay, gumbo	30	6	150	Drags, blade maintainers	Three times a month	60	Oil
Vermilion	Black dirt	30	6	125	Drags, graders	Once a week	90	None
Indiana:								
White	.....	20	4	425	Drags	Once a month	50	....
Iowa:								
Audubon	Clay	28	None	143	16′ blade tractor maintainer, horse maintainers, drags	Two or 3 times a week	90	None
Black Hawk	Clay, sand, sandy clay, gumbo	26	None	85	Drags, scrapers, patrol graders	Twice a week	50	None
Buchanan	Clay, gumbo	26	6	..	Drags, patrol graders, power maintainers	Daily unless very dry or wet	85 to 90	Heavy tractor treatment
Carroll	.....	28	..	190	Drags, patrol graders	Twice a week	90	None
Cerro Gordo	Clay	26	6	114	15′ heavy blade maintainer	3 to 6 times a week	50	....
Clarke	Clay	26	..	130	Tractor patrol, team drags	100 times a year	95	None
Dallas	Sand-clay, gumbo	26	None	..	Drags, maintainers	Twice a month	75	....
Guthrie	.....	24	6	128	Drags	Once a week	90	A little asphalt oil
Johnson	Clay	26	6	185	Drags, patrol graders	40 times a season	60	None
Osceola	Sandy clay, some gumbo	26	0 to 6	64	Drags	Once a week	75	12′ blade grader
Pocahontas	Gumbo, some clay	26	6	..	Each 3-horse 10′ blade grader handles 6 miles	....	Most	....
Winneshiek	Clay	26	None	81	Graders, drags, maintainers	....	50	....
Woodbury	.....	26	..	118	Drags, graders	Every 2 weeks	..	....
Kansas								
Greeley	Sandy loam	30	6	106	Drags, blade graders	Drags twice a month	90	....
Sheridan	Clay	28	4	60	Patrol blades, drags	Daily	98	....
Stevens	Clay, sand, gumbo	26	..	102	Drags	After each wet spell	..	Heavy maintainer
Michigan								
Crawford	.....	16	3	..	Scrapers	3 times a week	80	....
Gladwin	Clay, sand, sandy clay	24	9 to 12	36	Drags, scrapers, graders	....	6 months	None
Huron	Clay	..	..	6	Grader	4 times a month	3 days	....
Minnesota:								
Becker	Clay, sand, gravel	24	5	116	Patrol graders	Following rains	..	....
Douglas	Clay, sand	24	2½	191	Drags, small graders	Once a week	50	None
Meeker	All kinds	20 to 30	6	300	Graders	230 miles continuous	100	Resurfacing, heavy blading
Scott	Clay	24 to 30	None	9.5	Patrol graders, slip scrapers	3 or 4 times a week	While dry	....
Waseca	Loam	24	3	39	Patrol graders	....	..	....
Missouri:								
Buchanan	Clay, sand, gumbo	40	8	820	Drags, tractor blades	Whenever needed	75	Grading with 10-ton tractor
Cooper	.....	20	3	1,000	Drags, maintainers, graders	Whenever needed	While dry	None
Jasper	.....	24	12	320	Wooden drags, motor patrols, graders	Twice a month	75	....
Oregon	Gravely loam	15	6	..	Scrapers	....	4 to 6 mos.	....
Ozark	Clay, sand	..	..	800	Light graders	After each rain	Until next rain	....
Pettis	.....	24	6	500	Drags, scrapers, graders	Once a week	80	....
St. Charles	Clay, sand, gumbo	24	4	23	Drags, scrapers, graders	....	95	Oil
Shelby	Clay	25	..	1,000	Drags	2 to 5 times a month	75	Plow and scraper
Worth	Clay	24	..	300	Drags	When needed	80	None
Montana:								
Fergus	.....	20	4 to 6	825	Drags, graders, road fixers	Drag after each rain	75	Power blader
Roosevelt	Gumbo	22	..	220	Drags, small blades	After each rain	..	....
Nebraska:								
Franklin	Mixed	..	..	45	Drags, maintainers	....	80	....
Sherman	.....	..	..	125	Drags, maintainers	Once a month	..	....
Nevada:								
Lander	Alkali	20	12	34	Graders	6 times a year	40	....
New Jersey:								
Morris	Clay, sandy clay	20	12	40	Scrapers and graders drawn by tractors	3 times a season	66	....
New Mexico:								
Rio Arriba	All kinds	12	10	150	Drags, road maintainer	Twice a month	50	....
New York:								
Cortland	Clay, gravel	24	..	800	Tractors, scrapers, hones	Monthly	..	....
Jefferson	All kinds	24	8	..	Scrapers	3 or 4 times a year	40	....
Madison	Mostly clay	16	12	900	Hones, scrapers	10 days to 2 weeks	..	....
Oswego	Clay, sand, sandy clay	20 to 24	22	400	Hone, stone rakes	10 days to 2 weeks	50	....
Yates	Clay	16	3	650	Hones, disk harrows, maintainers	As needed	60	None

County	Kind of soil	Average width of graded sections, feet	Average crown, inches	Mileage kept in condition	Equipment used in keeping surface even	Frequency of treating a given stretch of road	Percentage of time road has a firm, smooth surface	Other treatment received by earth roads
North Carolina:								
Bertie	Clay, sand, sandy clay, gumbo	15-30	1 to 12	300*	Drags, road machines	Drag twice a week, machine twice a year	50	Sand in places; some corduroy
Mecklenburg	Clay, some sand	24	4	..	Tractors, road machines, graders	After each rain	75	None
Onslow	.....	..	..	200	Drags, trucks	10 days	75	None
Ohio:								
Carroll	Clay, sand, gravel, shale	10 to 28	0 to 6	910	Drags, scrapers	6 times a year	50	None
Delaware	Clay	20	6	87	Drags	Once a week	75	None
Fayette	Clay	10	2	150	Drags, scrapers, maintainers	10 times	..	....
Hamilton	.....	12	4	..	Graders	....	..	....
Harrison	Clay, sandy clay	20 & 28	12	700	Drags, scrapers	Every 3 or 4 weeks	50	Oil
Jefferson	Clay, sand, sandy clay	10	..	..	Drags, scrapers	Twice a year	5	None
Marion	Clay	18	10	200	Drags, scrapers	Twice a year	60	None
Union	Clay	20	8	85	Drags, scrapers	Spring and fall	Summer	None
Wyandot	Clay	12	4	..	Drags, scrapers, graders, maintainers, rollers	2 or 3 times a year	Dry weather	....
Oregon:								
Klamath	Sandy loam, pumice, dobie	24	8	..	Drags, scrapers	....	..	....
Wallowa	Clay, gumbo, sandy clay	20	5	1,100	Drags, blades, scrapers	3 or 4 times a year	6 months	....
South Dakota:								
Harding	Clay, sand, sandy clay, gumbo	24	5	460	Drag, patrol blades, scrapers	Weekly	75	....
Jackson	Gumbo, bad land soil	22	..	..	Patrol graders, small fresno	Twice a week	95	....
Stanley	Gumbo	24	3	200	Drags	3 times a month	80	None
Yankton	All kinds	40	6	100	2-way drags, patrol blades	Daily to once a week	80	None
Tennessee:								
Bradley	Clay, gumbo	..	..	..	Scrapers	Daily	100	....
Grundy	Clay, sand	24	None	25	Drags, scrapers	....	..	....
Hardeman	.....	..	..	200	Drags, graders	Once a week	After rains	....
Texas:								
Cameron	Sandy loam, black loam	24	..	500	Drags, graders	5 times a year	75	....
Harrison	Clay, sand	18	12	720	Drags, scrapers, fresnos, tractors	Twice a month	65	Repairs only
Jones	Sandy clay	22	..	360	Drags, tractors with 12′ blades	Drag after each rain, blade twice a year	2 months	None
Kent	Sandy clay	24	..	60	Drags, 12′ blades	After each rain	95	None
Utah:								
Sevier	Clay	20	9	20	Drags, graders	When needed	75	None
Virginia:								
Buchanan	Sandy clay	..	..	30	Drag, tractor graders		1 month	None
Fairfax	Gravel, black-jack clay	22	6 to 10	150	Steel and wood drags, patrol and large graders	State roads daily, county roads weekly	83	....
Mathews	Sand, gravel, gumbo	22	12	100	Drags, scrapers	After rains, about 10 days	..	....
New Kent	Clay	20 to 30	8 to 10	50	Drags, scrapers	Twice a month	67	None
Northampton	Sand, clay	24	..	40	Drags, scrapers	After each rain	..	Ditching, regrading
Smyth	Clay	18	6	50	Drags, road machines	Twice a year	50	....
Washington:								
Klickitat	Clay, sand, gumbo	16	4	300	Graders, drags	When necessary	9 months	None
West Virginia:								
Barbour	Clay, sand, sandy clay	..	..	50	Drags, scrapers	2 weeks	..	....
Monroe	.....	26	15	..	Scrapers, drags, trucks	Once a month	50	....
Wisconsin:								
Jefferson	Clay	..	..	300	Drags, scarifiers, graders	Daily	100	....
Marinette	Clay, sand	24	4	..	Patrol graders, power graders	Main roads daily, others 2 or 3 a week	100	None
Oneida	Clay, sand	24	5	..	Graders	Horse patrol daily, tractor every 2 days	90	None
Polk	Clay, sand	22	..	410	Scrapers, motor patrols	....	..	....
Rusk	Clay, sand, sandy clay	24	6	265	Patrol graders, motor patrol	Daily	100	....
Sauk	Sand, clay	24	8	393	Drags, graders	Continuous April to November	80	None
Taylor	Clay	25	8	96	Team graders, power patrols	Daily except wet weather	75	None
Trempealeau	Clay, sand	24	6	425	Drags, motor patrol, graders	Daily	75	None

*No roads graded; only cleared, stumped and pulled in with road machines.

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Purifying Small Water Supplies

A few years ago the south was lagging far behind the north in most of the modern refinements of community life, such as water supply, sewerage, improved paving of streets and roads, etc.; but many of the southern states have taken a spurt that is bringing them well up to northern standards, and along some lines they are even promising to surpass them. Among these latter may be included water supply and sewerage. Compare, for example, the number of sewage treatment plants in Texas with those in New England.

An article in this issue tells of the work done in Jefferson county, Alabama, in safeguarding the population against unsafe water. The county board of health maintains supervision over every supply serving fifty or more people, including industrial camps; these furnishing water for all the urban and 40 per cent of the rural population. And more than half of these supplies are treated although less than a third are surface supplies. One supply for a community of only twenty-six persons is both filtered and chlorinated.

Thousands of tourist camps in Maine, boarding houses and hotels in the White, Green, Adirondack, Catskill and Pokono mountains and the Berkshires in New England, New York and Pennsylvania house more than fifty persons each during the summer; while lumber camps and mining settlements of equal size can be found in many of the states on the North Atlantic seaboard. And we wonder how many of these are under careful supervision and how many even chlorinate their supplies.

Although there has been great improvement in this respect during the past few years we believe that many state and county officials fail to realize the importance of the water supplies of the small rural communities. It is not only that in the aggregate these communities contain a considerable percentage of the state's population as permanent residents, but fully fifty per cent of the urban population use their water supplies as transient dwellers during the summer months or as automobilists touring through them. Also the milk and green vegetable supplies of the cities come from the rural sections and a typhoid epidemic in the latter would be very likely to spread to the former through the medium of such foods.

The water supplies of the large cities are all under expert supervision. Every state should see to it that the small supplies are maintained equally safe.

Highway Culverts

Articles in this issue give some interesting conclusions derived from experiments and other investigations concerning culverts—their strength, rigidity, carrying capacity, materials prevalent in different counties and other features. Hundreds of thousands of culverts are built every year in connection with highway construction, and although one culvert may seem an insignificant structure, their number gives them an importance that calls for serious consideration.

Such consideration centers around two principal points—effectiveness and economy. Unless a culvert carries all the run-off of storm water that reaches it, such water will back up and tend to soften the embankment or even to overflow and evade the roadway surface; in ad-

dition to flooding private property in the vicinity. Economy means low ultimate cost for a culvert that meets the demands of the problem in question, involving durability as well as first cost.

One of the most interesting results of the tests of carrying capacity was the determination of the effect of rounding the edges at the entrance end of a culvert. It was found that such rounding increased the carrying capacity of a culvert from six to fifteen percent. The cost of such rounding was almost nothing. In fact, in some of the tests considerable increase was obtained merely by placing the bell end of a vitrified pipe at the upper end of the culvert instead of the spigot end. It seems to us that the importance of obtaining such a considerable advantage at insignificant cost would make it desirable to carry on further tests to develop the best manner of treating the inlet end to obain maximum efficiency with any given size.

Soil Temperatures in City Streets

Temperature of soil throughout the year at different depths at Clarksburg, W. Va., and frost penetration in various sections of the country.

"A Study of Year-Round Soil Temperatures from Zero to a Depth of Six Feet Below the Surface" was the subject of a paper read by Scotland G. Highland, general manager of the Water Board of Clarksburg, W. Va., before the convention of the American Waterworks Association. The paper contained the result of temperature readings taken in Clarksburg and also information obtained by correspondence with a number of cities. The author made this investigation because of the importance to a water department of accurate knowledge of frost penetration in city streets in order to determine the depth at which it is necessary to place water mains and services to avoid frost.

Thermometers for ascertaining the year-round temperature of subsoil at various depths were installed at Clarksburg, W. Va., on January 1, 1923. Six thermometers were used, one for each foot of depth investigated. They were installed in an abandoned, unpaved roadway representative of traveled street conditions. Each instrument consisted of a stout-stem thermometer enclosed in a wooden case, the upper front part of which was cut out, exposing an 11-inch scale. The thermometers ranged in price from $8 for that for 12-inch depth to $22 for that for 96-inch depth.

"The daily readings of these thermometers checked surprisingly well with the records of frost penetration in all parts of the city as found by frequent necessary excavations in the streets during and following protracted cold weather. Another severe winter like that experienced in 1917-18 will supply data of lasting worth."

Mr. Highland gave in his paper a tabulation of records of highest and lowest soil temperatures for each foot of depth and air temperatures at Clarksburg, from January 1, 1923, to April 30, 1926. Without giving the entire tabulation, which would require considerable space, it will be interesting to note the lowest soil temperatures and corresponding air temperature for each year, for each foot of depth.

In 1923, the lowest temperature at one foot was 32 degrees, in February; corresponding air temperature, zero. At two feet, the lowest was 35 degrees and for three feet the lowest was 36 degrees, both in February, with zero temperature. For four feet, the lowest temperature was 39 degrees in March, air temperature 12 degrees. For five feet the lowest temperature was 44 degrees in April, air temperature 7 degrees. For six feet the lowest was 46 degrees in April, air temperature 7 degrees.

In 1924, minimum soil temperatures were as follows: One foot depth, 33 degrees in January, air temperature —3 degrees. For two-foot depth 34 degrees in January, February and March, air temperatures —3, 9 and 16 respectively. Three-foot depth, lowest temperature 34 degrees in February and March, air temperatures 9 and 16 degrees. Four-foot depth, lowest temperature 36 degrees in February, air temperature 9 degrees. Five-foot depth, lowest temperature 40 degrees in February and March, air temperatures 9 and 16. Six-foot depth, lowest temperature 41 degrees in March, air temperature 16.

Minimum temperatures for 1925: One-foot depth low temperature 33 degrees in December, air temperature zero. Two-foot depth, 36 degrees in January and February, air temperature —8 and 6 degrees. Three-foot depth, 36 degrees in February, air temperature 6 degrees. Four-foot depth, 37 in January, air temperature—8 degrees. Five-foot depth, 40 degrees in February, air temperature 6 degrees. Six-foot depth, 42 degrees in January and February, air temperatures —8 and 6 degrees.

Lowest temperatures for 1926: One-foot depth, 32 degrees in January, air temperature —13. Two-foot depth, 34 degrees in January, air temperature —13 degrees. Three-foot depth, 35 degrees in February, air temperature 9. Four-foot depth, 39 degrees in February and March, air temperature 9 degrees and 5 degrees respectively. Five-foot depth, same as four-foot. Six-foot depth, 40 degrees in March, air temperature 5 degrees.

DEPTH OF FROST PENETRATION

Mr. Highland obtained from waterworks officials in many cities of the United States and Canada, information concerning their current practice as to laying watermains and services, their experiences as to freezing and the lowest

depth to which frost has penetrated in city streets.

Some Canadian cities reported as follows: Calgary: In 1916 frost penetrated to a depth of 12 feet in gravel and 8 feet in loam. Moose Jaw: Lowest frost penetration is under roadways where soil is firmly compacted, and in boulevards and on private property, where soil is looser, is 2 feet less than in abutting streets. Penetration twice as great in wet clay soils as in sandy soils.

Ottawa: Penetration 6 feet where there is considerable traffic. Depth of snow important.

Montreal: Penetration 5 feet or less, depending on nature of soil.

Among the North American cities, Leadville reported frost penetration 9 feet where gravel is loose, less in clay formation. Service pipes are laid in a double boxing from the main to the building. When frost reaches the service pipe, an upright boiler on wheels is employed to turn steam into the curb box, which follows the service through the boxing to the main and thaws out the pipe quickly. An early snow prevents serious freezing.

Davenport, Iowa: Penetration deeper on the south side of an east and west street than on the north. Water mains are laid on the north side.

Omaha, Nebraska: Depth varies greatly with amount of snow, with amount of moisture in the soil, and whether street is paved or unpaved.

Syracuse: Clay soils do not freeze as soon as sand and gravel.

New York City: Little frost penetration in paved streets. Particular care is taken to secure a good backfill in trenches excavated in loose material or in rock to prevent both freezing and unequal settlement. During winter of 1917-18, frost under asphalt pavement on concrete reached a depth of 2½ feet and under other pavements 3½ feet.

Glens Falls, N. Y.: Trouble with freezing where clay or heavy loam is found. Services in rock trenches have never given trouble.

Clarksburg, W. Va.: Frost penetration in 1917-18 reached a depth of 3 feet. Mains and services laid with 11 feet cover.

Bluefield, W. Va: Services have frozen under paved streets at depth of 2½ feet.

A tabulation is given of a considerable number of cities, showing the lowest depth of frost penetration in streets during the last 25 years, and the depth of which mains and services are now being laid. This shows a maximum depth of frost penetration of 12 feet at Calgary, Alta., and 11 feet at St. Paul, Minn. Nine feet is reported at Moose Jaw, Sask., Leadville and Duluth. Seven and one-half feet at Hazleton, Pa., and 7 feet at Winnipeg, Manitoba, Ft. Dodge, Ia., North Attleboro and Fitchburg, Mass., and Woonsocket, R. I. Among the minimum depths are Chatham, Ont.; Quincy, Ill.; Cincinnati, O.; Salt Lake City, Santa Fe, N. M., and Wellsburg and Wheeling, W. Va., 3 feet. Hagerstown, Md., 2 feet 8 inches. Kansas City, Mo.; New York City, and Bluefield, W. Va., 2½ feet. Everett, Wash., 1½ feet. Raleigh, N. C., 1 foot 3 inches.

The depths at which mains and services are laid at the present time vary from 10 feet to 2 feet. Ten feet in gravel and 8 feet in loam is reported by Calgary. Nine feet cover is reported by Moose Jaw. Eight and one-half feet was reported by Edmonton for mains and 7 feet for services. Eight feet was reported by St. Paul (to bottom of trench), Minneapolis (to axis of pipe). Seven and one-half feet cover was reported by Regina, Sask.; Winnipeg and Duluth (both mains and services). Seven feet cover was reported by Leadville, Colo., and Bismarck, N. D. Six and one-half feet cover was reported by Ottawa, Ont.; Springfield, Mass., and Butte, Mont.

Coming to the shallower trenches, we find 2 feet cover reported by Jackson, Miss.; 2½ feet cover by Atlanta, Ga. (services 2 feet); Baton Rouge, La.; Richmond, Va., and Everett, Wash. Three feet cover was reported by Wilmington, Del.; Louisville and Frankfort, Ky.; Hagerstown, Md.; Santa Fe, N. M.; Johnstown and York, Pa.; Wheeling, Parkersburg, Charleston and New Martinsville, W. Va.

Four to six feet was more common than any of the others and was reported by 85 cities.

Discussing the subject, Mr. Highland stated that it is not in the mains, but in the services that most of the trouble from freezing occurs, because these are frequently laid at considerably less depth than the mains.

"Water mains in the gridiron system of the distribution lines, having good circulation, seldom freeze; but dead ends and shallow services in streets and under sidewalks and lawns, often privately laid and maintained, cause trouble."

"Soil thermometers installed at a location typical of traveled roadways will give low temperature warnings throughout the confines of a city equipped with these instruments." Greater depth of main has other advantages. At lower depths the ground temperature is more uniform and thus contraction and expansion of the pipes in less; the deeper pipes are laid, the less susceptible they are to electrolysis; if laid at a minimum depth of 5 feet they will generally be below the depth of other utilities (excepting sewers) and thus will not be disturbed by those digging to reach these other utilities; soil at the lower depths is ordinarily more free from impurities affecting the life of the pipe, especially where there has been a filling with cinders or other materials having a tendency to corrode the pipe.

Cleaning Sewers in Atlantic City

Chester G. Wigley of Atlantic City, New Jersey, at this year's annual meeting of the New Jersey Sewage Works Association, told of experience in keeping clean the sewers of that city, where the system is privately owned. Here, as in many resort comunities along the seashore, the sewers were necessarily laid at the very lowest grade possible in order to avoid heavy pumping charges, many of them being at grades of one in one thousand and some even one in two thousand. Not all the joints were tight and as

the soil is a very fine sand, more or less of this is found to enter the sewer. At one point the sewer was carried under a railroad track, cast iron being used; but later the railroad extended some sidings across the street at this point, some of them being over the vitrified clay pipe, with the result that this was cracked and a great deal of sand leaked into the sewer.

Another cause of difficulty in this city is the great amount of grease discharged from the kitchens of the large hotels. Where a sewer is running nearly full at times, a great deal of grease will gradually accumulate on the top of the sewer, entering the sewer while hot and being cooled off by contact with the pipe. Last year an eight-inch sewer was removed which received the sewage from a restaurant and was found to be entirely filled with grease except for a depth of about two to three inches. These conditions are found all through the densely populated sections of the city and it is necessary to scrub the sewers, in most cases once a year and in some cases twice. This costs one cent a foot in some cases and in others up to ten or fifteen cents a foot. Ten barrels of grease were recently removed from one block of fourteen-inch pipe, this being one which received the sewage from three of the cities' largest hotels. In removing the grease, coil spring scrubbers are generally used, the diameter being two or three inches less than that of the pipe, these being dragged back and forth until all the grease is removed.

Asked whether there was not some way of preventing grease entering the sewers, Mr. Wigley stated that it is difficult to get hotel or restaurant owners to install and maintain grease traps. All hotels and restaurants are required to have these and if the trap is say, ten by six feet and is cleaned regularly it is usually satisfactory in keeping grease out of the sewers. The difficulty is that the hotels and restaurants can not be depended upon to clean the traps regularly and this is usually done by the company at a nominal cost to the hotel; but it is believed to be better from the health stand point and that of offensiveness to let the grease into the sewer. Some smaller places put in grease traps furnished by plumbers, usually a cast iron pot about twelve inches in diameter, but these are effective for only about one day. John R. Downes, of the Plainfield plant, stated that he also had decided that it was less of a nuisance to let the grease come on down to the plant than to get individuals to take care of it.

Tests of Concrete in Tension*

To obtain data as to relative strength in compression and tension. Ratio practically constant at 8 percent when more than 90 days old.

By A. N. Johnson†

The tests here described are the result of cooperative work between the University of Maryland, the State Roads Commission of Maryland, and the United States Bureau of Public Roads.

The purpose was to obtain more data as to the relative strength of concrete specimens in compression and tension, the tension specimens to have a cross-sectional area equal to those of the compression specimens.

To do this required special apparatus which was designed and made in the shops of the University of Maryland. Each tension specimen consists essentially of a cylindrical section, on each end of which inverted frustums of cones were made, so that the total length of the specimen was nearly 21 inches. The cylindrical portion of the specimen was the size of the cylinders used in the compression tests, 9 inches long by 4½ inches in diameter. The tension test specimens were cast in brass moulds which were split their entire length and bolted together. Before casting a specimen, the moulds were rubbed with an oily rag. The concrete was put in from one end and tamped with a rod. As the concrete was placed in the moulds, they were hit with a wooden mallet which resulted in a concrete free from small air pockets. The compression specimens were cast in steel moulds which were made by splitting seamless tubing along one element of the cylinders and holding the edges together by means of bolts attached to lugs. Compression specimens were tamped as the concrete was poured in one end and these moulds also were struck with a wooden mallet.

From a given batch of concrete, three specimens were made to be tested in compression and three in tension. No particular care was taken, however, that subsequent batches should have the same water ratio. The quartz sand used contained 4 to 5 per cent of silt, wet measure, and a trace of inorganic impurities, and had a fineness modolus of 3.28. The coarse aggregate was limestone not exceeding 1 inch in size, with a fineness modulus of 6.20.

APPARATUS FOR TENSION TEST

In the design of the apparatus to hold the tension specimen, special care was taken to insure that the geometric axis of the tension specimen should coincide with the line of force applied to the specimens by the testing machine. For this purpose there had been made a split aluminum cylinder of inside diameter and length equal to the diameter and length of the cylindrical portion of the tension specimen;

*Paper presented at annual meeting of American Society for Testing Materials.

†Dean, College of Engineering, University of Maryland.

and two conical, split, brass ends the smaller diameter of which was sufficient to permit them to be passed over the ends of the test specimen. In preparing the specimen for testing the aluminum cylinder was placed around the cylindrical portion and held in place by a wooden clamp. The brass ends, their two halves bolted together, were then passed over the conical ends of the specimen until they rested on flanges provided at the ends of the aluminum cylinder, using this cylinder to center them with reference to the axis of the specimen. There was thus left an annular space between the brass end pieces and the specimen, which was filled with molten rosin poured through holes in the top of the brass ends. As soon as both end pieces had

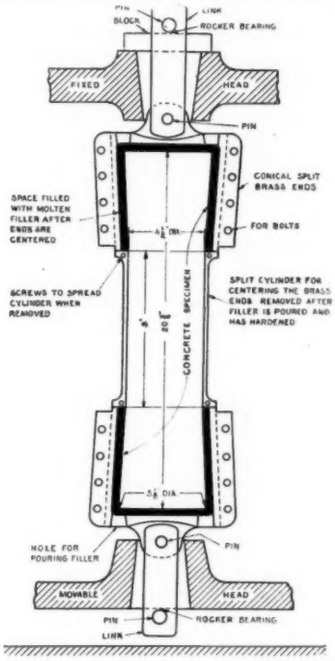

FIG. 1.—DIAGRAM SHOWING THE ARRANGEMENT OF THE SPECIMEN AND THE APPARATUS FOR THE TENSION TEST.

been thus placed, the aluminum centering cylinder surrounding the center portion of the specimen was removed. Reference to Figure 1 will show the arrangement of the specimen and the apparatus. The diagram shows clearly how, by means of links and pins with rocker bearings, the specimen was mounted in the machine in such a manner that there was no twist or eccentric loading of the specimen during the application of the load.

The compression tests were made with a spherical bearing block and usually a very thin cap of plaster was applied to the ends to insure flat bearings.

A 100,000 pound Riehle machine was used for these tests, the load being applied slowly by hand at a rate not exceeding 10,000 pounds per minute. In operation, the apparatus worked very satisfactorily.

The specimens were stored in damp sand for about two weeks and then removed to a room in the laboratory. They were tested at various ages up to 8 or 9 months.

The lack of any attempt to control the water ratio and the comparatively short period of curing accounts for the irregularity in the results when compared with the age of specimens. As it was the intent primarily to study the ratio of tension to compression strengths, it was not necessary, in fact it was probably better, that there should be a variety in the specimens that would correspond with variations that might be expected in most commercial work.

Practically all the concrete tension specimens broke within or near the middle third of the cylindrical portion of the specimen, whereas a greater number of the mortar tension specimens broke near one clip or the other. In all instances, the breaks were nearly planes perpendicular to the axis of the specimen.

RESULTS OF THE TESTS

The results obtained are detailed in Tables 1 and 2. Table 1 shows the results for the mortar specimens, which were mixed 1 part cement to 2 parts sand. Table 2 shows the results obtained with concrete mixed 1 part cement, 2 parts sand, and 3 parts coarse aggregate. From the tables it will be noted, first, that the ratio of tensile to compressive strength is practically the same for the mortar specimens as for the concrete, and, second, that for specimens up to 90 days old the ratio in each case varies from about 15 per cent to about 8 per cent, and after this period, the ratio becomes practically constant at 8 per cent. It is apparent that during the first 60 to 90 days the increase in tensile strength is not as great as the increase in compressive strength, but beyond this time it appears that both are modified in practically the same ratio. The relation of these results is shown in Figure 2.

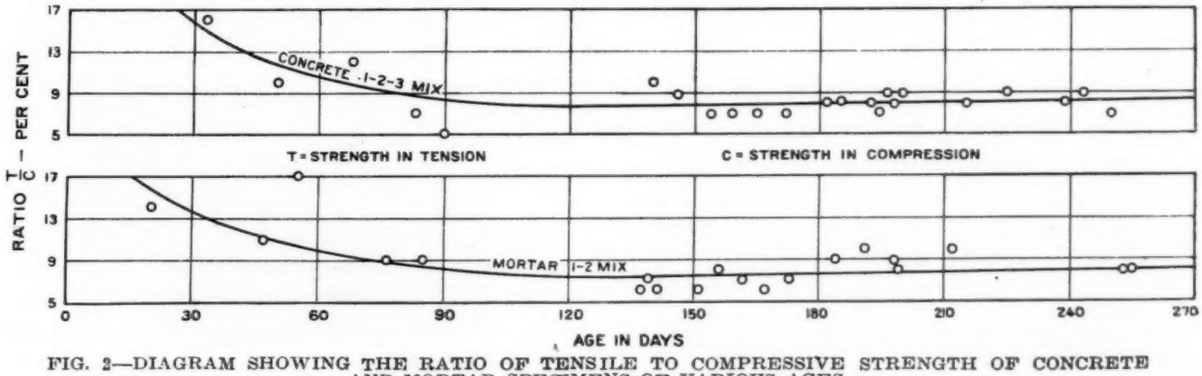

FIG. 2—DIAGRAM SHOWING THE RATIO OF TENSILE TO COMPRESSIVE STRENGTH OF CONCRETE AND MORTAR SPECIMENS OF VARIOUS AGES

The agreement of the results seems so persistent, over such a wide variation in the character of the concrete that there is considerable definite evidence as to the ratio between the tensile strength and compression strength. Thus, in any given case the compression strength being determined, the tensile strength is made known with sufficient accuracy for most purposes.

During these experiments, a few measurements were made to determine the elastic curve of the concrete in tension. It is, perhaps, sufficient here to state a few of the results obtained.

Table 1.—Results of compression and tensile strength tests of cement mortar, 1:2 mix.

[Cross-sectional area of specimens, 16 square inches (approximately). Each result the average of tests of three specimens]

Age	Compressive strength	Tensile stren'h	Ratio tensile to compressive strength	Age	Compressive strength	Tensile Stren'h	Ratio tensile to compressive strength
	Lbs. per sq. in.	*Lbs. per sq. in.*	*P.c.*		*Lbs. per sq. in.*	*Lbs. per sq. in.*	*P.c.*
20 days	2,510	349	14	162 days....	6,123	399	7
47 days	3,827	421	11	167 days....	6,750	431	6
55 days	2,640	442	17	173 days....	7,133	466	7
76 days	4,990	434	9	184 days....	5,790	525	9
85 days	4,200	370	9	191 days....	6,340	630	10
137 days	6,230	347	6	198 days....	5,420	494	9
139 days	7,140	490	7	199 days....	5,873	496	8
141 days	7,188	434	6	212 days....	5,613	541	10
151 days	7,577	488	6	253 days....	6,663	547	8
156 days	7,223	583	8	255 days....	6,183	505	8

Table 2.—Results of compression and tensile strength tests of cement concrete, 1:2:3 mix.

[Cross-sectional area of specimens, 16 square inches (approximately). Each result the average of tests of three specimens]

Age	Compressive strength	Tensile stren'h	Ratio tensile to compressive strength	Age	Compressive strength	Tensile stren'h	Ratio tensile to compressive strength
	Lbs. per sq. in.	*Lbs. per sq. in.*	*P.c.*		*Lbs. per sq. in.*	*Lbs. per sq. in.*	*P.c.*
18 days	1,297	...	..	181 days....	1,847	155	8
33 days	2,160	349	16	185 days....	4,280	326	8
50 days	3,197	335	10	192 days....	3,773	301	8
69 days	3,043	360	12	194 days....	4,667	307	7
83 days	3,007	220	7	196 days....	2,130	192	9
90 days	2,503	126	5	197 days....	2,863	235	8
140 days	3,353	334	10	200 days....	2,503	236	9
146 days	4,160	369	9	215 days....	4,260	330	8
154 days	4,175	293	7	225 days....	3,337	298	9
159 days	3,310	244	7	239 days....	3,647	284	8
165 days	3,473	257	7	243 days....	2,797	247	9
172 days	3,023	231	7	249 days....	3,373	248	7

The deformations in tension were observed by means of a mirror extensometer attached in a manner similar to that described for observations of compression cylinders in a paper by the author to be found in the A. S. T. M. Proceedings, volume 24, 1924, part 2, page 1025.

As illustrative of some of the results obtained, Figure 3 shows the deformations obtained upon a

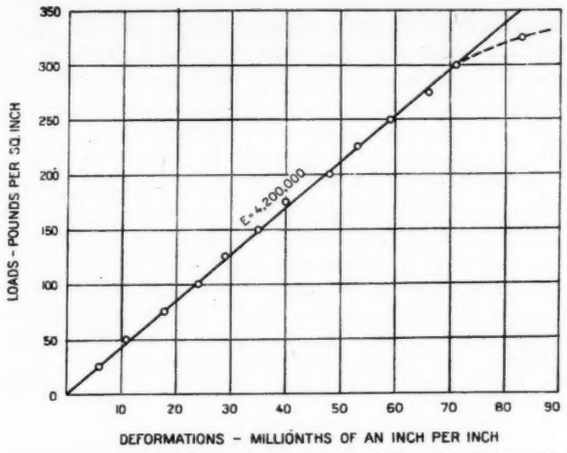

FIG. 3—RELATION OF LOAD TO DEFORMATION OF A 1:2 MORTAR SPECIMEN TESTED IN TENSION

1:2 mortar specimen, which broke at 340 pounds per square inch, and indicates a modulus of elasticity of 4,200,000 pounds per square inch. The values of E for the few specimens tested varied from 3,300,000 to over 5,000,000 for some specimens.

It is the expectation to carry on a more extended series of observations of the modulus of elasticity of concrete in tension, particularly with Lumnite cement.

Tests of Reinforcing Bars*

Allowances that should be made for variation between actual and nominal areas of deformed bars.

By D. O. Woolf†

In testing steel reinforcement bars, it has been the custom in many laboratories to assume that the cross-sectional area of the bar is that given in the manufacturers' tables. It has been found that, in the case of the deformed bar, the nominal area seldom agrees with the actual area, and that occasionally the difference is so great that serious errors may result from the assumption of equality. To insure more accurate tests of the physical properties of steel, the physical laboratory of the Bureau of Public Roads has adopted the practice of making planimeter measurement of the cross-sectional area of all concrete reinforcement bars submitted for test. The higher allowable unit stresses used in designing at the present time together with a desire for more rigid laboratory control have demanded that this greater care be used in determining the bar cross section.

The method used in the determination of the actual area is simple. The test specimen is cut through at right angles to its axis, and the cut

*From "Public Roads," official publication of the Bureau of Public Roads.

†Junior Material Engineer, U. S. Bureau of Pubilc Roads.

surface is filed smooth. An impression of this surface is made by the use of carbon paper or stamp pad, and the area of the print is determined by polar planimeter measurement. In the case of bars of very irregular shape, several different sections are measured.

The standard specifications for billet-steel concrete reinforcement bars (serial A15-14) of the American Society for Testing Materials permit the testing of bars turned down to a uniform cross section. This method of testing deformed bars has the objectionable feature of requiring the use of a lathe which may not be available at the laboratory. By the use of the planimeter the cross-sectional area may be determind so accurately that the turning down to uniform diameter will not be necessary.

The table shows certain data from some of the more recent tests made by the bureau. The unit tensile strength has been computed using both the nominal and actual cross-sectional areas. In several cases, had the nominal area been used the bar would have been classed as other than its true grade of steel. For example, samples 6 to 8, inclusive, were submitted as ½-inch round bars. Measurement of the cross-sectional area gave 0.25 square inch in each case, and computation of the test values gave unit tensile strengths corresponding to the structural grade. Using the nominal area of a ½-inch round bar, unit tensile strengths in the intermediate grade were obtained. As the specifications for this project required the structural grade, the steel would have been rejected had the nominal area been used.

Comparison of Actual and Nominal Cross-sectional Areas of Bars and Unit Strengths Based on Each

Sample No.	Size and shape of deformed bar	Area of cross section		Breaking load	Unit tensile strength		Error in nominal unit tensile strength	
		Nominal	Actual		Nominal	Actual		
		Sq. ins.	Sq. ins.	Pounds	Lbs. per sq. in.	Lbs. per sq. in.	Lbs. per sq. in.	Per cent
1	½-inch square...	0.25	0.20	12,140	48,560	60,700	12,140	20.0
2	⅜-inch round....	.11	.16	10,990	99,910	68,690	31,220	45.4
3	½-inch round....	.20	.25	15,320	76,600	61,280	15,320	25.0
4	½-inch square...	.25	.23	14,590	58,360	63,430	5,070	8.0
5	¾-inch round....	.44	.41	24,740	56,230	60,340	4,110	6.8
6	½-inch round....	.20	.25	15,620	78,100	62,480	15,620	25.0
7	½-inch round....	.20	.25	15,650	78,250	62,600	15,650	250.
8	½-inch round....	.20	.25	15,560	77,800	62,240	15,560	25.0
9	¾-inch round....	.44	.43	36,260	82,410	84,330	1,920	2.3
10	1-inch square....	1.00	.98	61,820	61,830	63,080	1,260	2.0

H-ION BLOCK COMPARATOR.

Hydrogen Ion Control in Water Purification*

Non-technical description of procedure of determining the pH value of a sample of water by comparison with colored indicators.

The fact that control of acidity is one of the most important factors in the various steps of the water purification process has been known for a long time. It is only within the last few years, however, that the inaccuracy of the old methods of testing and the need for more accurate control have been realized. This need has been adequately filled by the introduction of hydrogen ion control methods.

Since the subject of hydrogen ion control is so new, many workers have felt that its application to the various industries requires the services of a highly trained chemist. It is the purpose of this paper to show that it is just as simple to make a determination of hydrogen ion concentration as it is to make a measurement of temperature, and that these measurements can be made just as easily and accurately by a plant foreman as by a trained chemist.

MEANING OF pH SCALE

On the fahrenheit thermometer 32° represents the freezing point of water. Any values higher than 32°, such as 34°, 36°, 40°, etc., denote an increase in heat, the degree of heat *increasing* as the numbers *increase*. On the other hand, any values below 32°, such as 30°, 28°, 20°, etc., denote an increase in coldness, the degree of coldness *increasing* as the numbers *decrease*.

In an exactly similar manner the degree of acidity or alkalinity is expressed by the hydrogen ion scale, the units on which are called pH values. The meaning of the term "pH" is immaterial for the use of this method of measuring acidity and alkalinity. On this scale a value of pH 7.0 represents neutrality; that is, a material having a pH value of 7.0 is neither acid nor alkaline. Any values higher than pH 7.0, such as pH 7.2, 7.4; 8.0, 9.0, etc., denote alkalinity, the degree of alkalinity *increasing* as the numbers *increase*; and any values lower than pH 7.0, such as 6.8, 6.6, 6.0, 4.0, 2.0, etc., denote

*Condensed from paper before American Water Works Association, by W. A. Taylor, president Lamotte Chemical Products Co.

COLOR STANDARDS.

acidity, the degree of acidity *increasing* as the numbers *decrease*.

To give a concrete example, let us say that a solution has a pH value of 7.6. The solution is slightly alkaline and it is necessary to add a definite quantity of acid to it in order to bring it to the neutral point of pH 7.0, and larger quantities of acid to bring the solution to an acidity of 6.8, 6.0, etc. Similarly, if a solution has a pH value of 6.0 it is acid, and it is necessary to add alkali to it in order to bring it to the neutral point of pH 7.0, or to an alkaline value such as pH 8.0.

It is, therefore, necessary only for the operator to know what pH value should be maintained in a given operation and how to determine when sufficient acid or alkali has been added to obtain this value.

The importance of accurate control of acidity in coagulation is well known. In addition acidity has a great effect in practically all of the other operations, such as softening, after-treatment to prevent corrosion in the distributing system with resulting red water, in all bacteriological work, etc.

COAGULATION

Coagulation takes place best at a definite pH value, this value being different for different waters, since it is affected by the color and turbidity of the water, the natural alkalinity, buffer action, etc. For example, the optimum for waters in one state varies from 4.2 to 7.6. This point can be determined most easily and satisfactorily by means of the "jar test," which was fully described by Catlett, "Journal of the American Water Works Association," Vol. II, page 887, July, 1924. By this procedure the optimum pH value for a given water is determined and if it is maintained the smallest possible amount of alum necessary to give the best and quickest floc is used at all times, so that a good floc is obtained but no alum wasted. In a number of purification plants hydrogen ion control has resulted in reducing the alum to less than one-half that ordinarily used.

The optimum may change with the season, the temperature of the water, change of source of supply, etc. If at any time, therefore, a good floc is not obtained, the optimum should be redetermined.

It should be remembered that poor coagulation may be caused by an over as well as an under dose of coagulant. Coagulation at the optimum means a better filter effluent, as it eliminates practically all solvent action on the floc and the appearance of aluminum in the effluent. It also ensures a higher bacterial efficiency, increases the rate of filtration and makes possible a decrease in the size of the coagulating basin. It also of course means that the maximum efficiency is obtained from the chemicals used, without any waste.

The argument has been advanced that in many cases good coagulation can be obtained over a very wide range and that, therefore, hydrogen ion control is not necessary for efficient operation. The fact is overlooked that for just this reason it is very much easier to add a large excess of alum than in the case where the range for a good floc is very narrow.

Hydrogen ion control has now been sufficiently widely adopted to prove beyond doubt that the old methods of testing give erroneous and misleading results, and that there are few, if any, waters to which it cannot be advantageously applied.

METHOD OF MAKING MEASUREMENTS

Block Comparator.—Everyone knows that if litmus paper is dipped into a solution and the paper turns red, the solution is acid. If, on the other hand, the litmus paper turns blue, the solution is alkaline. Litmus paper is, however, very insensitive and gives no definite idea of the exact degree of acidity or alkalinity. By means of hydrogen ion measurements, however, the slightest change in acidity or alkalinity can be detected, and even slight changes often mean the saving or loss of large amounts of chemicals. The principle of hydrogen ion measurements depends on the fact that various indicators give changes in color, depending on the degree of acidity or alkalinity of the material to which they are added.

Different indicators are used to cover different parts of the pH scale. For example, bromthymol blue covers the part of the range pH 6.0 to 7.6. If a small amount of a solution of this indicator is added to a water which it is desired to test, the color obtained will indicate whether the water is acid or alkaline. If a yellow color is obained the water is acid. If a blue color is obtained the water is alkaline. If, however, an intermediate color is obtained, the water is either neutral or very slightly acid or alkaline. To determine the exact degree of acidity or alkalinity, all that is necessary is a set of color standards, a comparator box, a supply of bromthymol blue indicator solution and a few graduated test tubes. A set of color standards for bromthymol blue consists of nine standard tubes, and one tube of distilled water.

The nine standard tubes are marked with the values pH 6.0, 6.2, 6.4, 6.6, etc., up to pH 7.6, in intervals of 0.2 pH. The tube marked pH 6.0 has a yellow color, and that marked pH 7.6 a deep blue color. The tubes between these two extremes show intermediate colors, the blue shade increasing in intensity as we go from pH 6.0 to 7.6. It is necessary only to fill one of the test tubes to the mark (10 cc) with the water to be tested, add to it 0.5 cc. of the bromthymol blue indicator solution by means of the graduated pipette and nipple, and compare with the color standards, when the pH value, that is the degree of acidity or alkalinity of the water, is read off directly from the tube with which it matches.

Since many waters which are encountered are colored or turbid, or both, the comparator box has been so designed that the effects of color

and turbidity are eliminated and an accurate match with the standards obtained. By referring to Fig. I, it will be seen that the top of the case serves as the comparator block. It is removed, leaving all of the remaining equipment in the bottom of the case. We shall designate the six holes back of the three slots in the side of the comparator block as A, B, C, and D, E, F, respectively.

In making a determination, three of the graduated test tubes are filled to the mark (10 cc) with the water to be tested, and the tubes are then placed in the three holes on one side of the block, as at A, B and C below.

A B C

D E F

Then 0.5 cc. of the bromthymol blue indicator is added to the tube at B and the contents thoroughly shaken. The tube of distilled water is then placed in the hole marked E and two color standards, differing by only 0.2 pH, for example, 6.8 and 7.0, are inserted in the holes D and F. If, on looking through the three pairs of tubes, holding the block toward the light, the central pair of tubes exactly matches either of the other pairs, the pH value of the water is read off directly from the standard with which the match is obtained. If, however, the color of the central pair of tubes lies between the colors of the pairs on either side, the pH value is taken as the average of the two. For example, if it lies between 6.8 and 7.0, the value is taken as 6.9.

In the above example, if the color through the central pair of tubes is bluer than either of the other pairs, the tube marked pH 6.8 is removed and the one marked pH 7.2 inserted in its place, and so on until a match is obtained. If, on the other hand, the central pair of tubes is a lighter blue than either of the other pairs, the tube marked pH 7.0 is removed and the one marked pH 6.6 inserted, etc.

By the above arrangement, after the proper standard has been inserted, a match must be obtained, since the worker is looking through exactly the same materials in each pair of tubes. To make this clear, the color standards may be considered as made up of water and indicator solution. They do of course contain solutions of salts to give them definite degrees of acidity and alkalinity, but, since the solutions of salts from which they are made are colorless, they can be considered as made up of only these two materials.

Suppose we are testing a water which is brown in color. We shall designate this brown water by "X," clear water by "W" and the indicator solution by "I." The contents of the test tubes and color standards may then be represented as follows:—

X X X
I

I I
W W W

It will be seen that each pair of tubes contains the brown water "X," indicator solution "I" and clear water "W," the only difference being that the indicator solution has been added to the brown water in the central test tube, instead of to the distilled water tube placed in front of it. The final combination is, however, the same in all pairs.

If, on adding the bromthymol blue indicator solution to the sample to be tested, a yellow color were obtained, it would show that the sample was as acid as pH 6.0 and possibly more so, since 6.0 is the acid end of the range of this standard. Therefore an indicator covering a more acid part of the scale must be tried, for example, bromcresol purple, which covers the range pH 5.2 to 6.8, the color change being from yellow at pH 5.2 to a deep purple at 6.8. The comparison with the bromcresol purple color standards is made in exactly the same manner as that described above for bromthymol blue. If bromcresol purple gives a yellow color, the next indicator, bromcresol green, which covers a still more acid part of the range, pH 4.0-5.6, should next be tried. The one comparator block can of course be used with as many sets of color standards as desired.

Analogously, if on adding the bromthymol blue indicator solution to the sample to be tested, a deep blue color were obtained, the solution would be as alkaline as pH 7.6, and possibly more. The test should therefore be repeated using phenol red, which covers the lower part of the alkaline range, pH 6.8 to 8.4, etc. The various indicators with their ranges and color changes are given below:

Name	pH Range	Color Change
Metacresol Purple	1.2-2.8	Red-Yellow
Bromphenol Blue	3.0-4.6	Yellow-Blue
Bromcresol Green	4.0-5.6	Yellow-Blue
Bromcresol Purple	5.2-6.8	Yellow-Purple
Bromthymol Blue	6.0-7.6	Yellow-Blue
Phenol Red	6.8-8.4	Yellow-Red
Cresol Red	7.2-8.8	Yellow-Red
Thymol Blue	8.0-9.6	Yellow-Blue

It will be seen from the table above that the ranges of most of the indicators overlap, so that it is usually possible to make a determination on the same material with two different indicators, and thus check the accuracy of the measurement.

The range required for general water purification work is covered by the three indicators, bromcresol purple, bromthymol blue, and phenol red. One block comparator set, with two extra sets of color standards, together with a supply of the corresponding indicator solutions, and a few test tubes and marked pipettes are all the equipment necesssary for this work.

Roulette Comparator.—In response to the request of a large number of water purification plants, as well as many other industries, for a set covering an extended range, which would give the maximum of simplicity, accuracy and speed in making hydrogen ion determinations, the H-Ion roulette comparator was developed.

In this equipment the color standards, covering the ranges of the three indicators, bromcresol purple, bromthymol blue, and phenol red, are placed in the revolving drum, the color standards alternating with ampoules of distilled water.

The block on the front of the stationary metal band holds three 10 cc. test tubes for the material to be tested, and contains three slots for making color comparisons.

H-ION ROULETTE COMPARATOR.

Just as in the case of the block comparator, the three test tubes are filled to the mark (10 cc) with the water to be tested. Then 0.5 cc. of the proper indicator solution is added to the middle one, by means of the graduated pipette and nipple, the proper indicator having been previously determined as described above. The drum is then revolved until the corresponding color standards are behind the test tubes and a color match is obtained. The pH value is then read off directly from the standards, as the labels project above the top of the drum.

The set is fitted with a 40 watt Mazda lamp, an etched glass and a daylight glass screen, thus ensuring the same standard daylight condition whether readings are made during the day or night. The bottles of indicator solution, each fitted with a pipette and nipple, and eighteen graduated test tubes are contained in a separate box.

A fourth set of color standards, such as bromcresol green, may be obtained if required. For the less frequent measurements with this indicator, one of the sets of standards is removed from the drum and the extra set of standards substituted.

With this equipment the danger of breaking color standards from handling is practically eliminated, and determinations can be made with the maximum of speed and the minimum of effort. In addition, measurements made at night and on dark days are just as accurate as those made on bright days.

Water Works Statistics for 1925

Reports from two hundred cities, supplementing those from four hundred published in the June issue. Meter rates and percentage of services metered; chemicals used in water purification; sizes of mains laid and kinds of pipe used.

Meter Rates and Percentage of Services Metered

City	Percentage of Services Metered	Maximum Rate: Cents per 100 cu. ft. (c) or 1,000 gal. (g)	Maximum Rate: For Consumption less than	Minimum Rate: Cents per 100 cu. ft. (c) or 1,000 gal. (g)	Minimum Rate: For Consumption more than	Average Rate of all Metered Water—Cents
Alabama:						
Talladega	100	25 g	5,000 per quarter	12½	18,000 per quarter	....
Arizona:						
Glendale	65	$2.00 c	7,500 per month	$2.00	.....	....
Prescott	100	$1.00 g	.....	25 g	.....	....
Tuscon	65	30 g	5,000 per month	12 g	5,000 per month	....
Arkansas:						
Harrison	90	35 g	10,000 per month	15 g	100,000 per month	....
California:						
Anaheim	99	13⅓c	750 per month	10 c	750 per month	....
Benicia	100	55 c	300	33 c	10,000	41 c
Burlingame	100	35 g	15,000 per month	32 g	50,000 per month	....
Coalinga	20	....	.....	....	.....	....
Dinuba	98	9 c	3,000	7 c	3,000	....
El Centro	100	15 g	.....	15 g	.....	....
Long Beach	100	15 c	500 per month	5 c	100,000g per month	....
National City	100	25 c	1,000 per month	5 c	2,000 per month	7.9 c
Pittsburg	100	....	.....	35 c	500	....
San Francisco	100	28.8c +meter rent	3,300	21.6 c+ meter rent	33,300	....
Ventura	60	22 c	500 per month	4 c	51,000 per month	....
Colorado:						
Alamosa	98	27 g	5,000 per month	12 g	60,000 per month	....
Boulder	14.84	20 g	75,000 per quarter	5 g	1,000,000 per quarter	10.8 g
Canon City	....	25 g	25,000 per month	6 g	70,000 per month	10 g
Denver	2	17 g	15,000 per month	8 g	20,000,000 per month	10.3 g
Connecticut:						
Bristol	99	18 c	10,000 per quarter	7 c	400,000 per quarter	....
Hartford	100	15 c	3,000 per day	7½c	3,000 per day	14 c
Florida:						
Live Oak	60	$1 c	.....	15	3,000 per month	....

City	Percentage of Services Metered	Maximum Rate: Cents per 100 cu. ft. (c) or 1,000 gal. (g)	Maximum Rate: For Consumption less than	Minimum Rate: Cents per 100 cu. ft. (c) or 1,000 gal. (g)	Minimum Rate: For Consumption more than	Average Rate of all Metered Water—Cents
Georgia.						
Albany	100	20 g	30,000 per month	....	.....	....
Carrolton	100	33 c	1,000 per month	10 c	3,000 per month	22 c
Dalton	70	25 g	2,000 per month	10 g	7,000 per month	18 g
Fort Valley	100	20 g	All	20 g	.....	20 g
Griffin	100	19 g	50,000 per month	14 g	500,000 per month	21½ g
Newnan	100	25 g	10,000 per month	10 g	300,000 per month	....
Pelham	100	34 g	50,000 per month	16 g	50,000 per month	....
Sylvester	90	30 g	50,000 per month	15 g	50,000 per month	....
Illinois:						
Bloomington	90	40 g	100,000 per quarter	12 g	700,000 per quarter	....
Cairo	15	25 c	7,500 per month	8 c	200,000 per month	....
Canton	100	40 g	50,000 per quarter	35 g	.....	....
Chester	50	$1.50	1,000 per month	50 g	1,000 per month	....
Clinton	95	....	.....	....	.....	....
Geneva	100	30 c	3,000 per quarter	15 c	6,000 per quarter	....
Herrin	50	$1.75 g	1,000	35 g	300,000	....
Johnston City	100	75 g	5,000 per month	15 g	600,000 per month	....
La Salle	100	20 c	1,500 per quarter	9 c	4,000 per month	18 c
Lockport	100	70 g	5,000 per quarter	60 g	5,000 per quarter	....
Macomb City	96	50 g	1,000 daily	25 g	30,000 daily	30½ g
Melrose Park	95	30 g	.....	13½ g	50,000 industrial	....
Morrison	30	25 g	50,000 per quarter	10 g	400,000 per quarter	....
Paris	10	37½ g	30,000 per quarter	9 g	500,000 per quarter	....
Rushville	100	50 g	1,000	50 g	1,500	....
Sandwich	100	30 g	4,400 per day	10 g	10,000 per day	....
Watseka	100	30 g	50,000 semi-annually	15 g	50,000 semi-annually	....
White Hall	100	35 g	20,000 per month	7	5,000,000 per month	....
Woodstock	95	30 g	5,000 per quarter	....	.....	....
Indiana:						
Boonville	4	50 g	5,000 per month	10 g	100,000 per month	16 g
Delphi	85	40 g	.....	7 g	.....	21.6 g
East Chicago	100	28.3 g	10,000 per month	5.85g	3,000,000 per month	....
Elwood	85	29 g	All	27 g	All	....
Fort Wayne	100	12 c	417 per month	4.875c	23,750 per month	11.9 g
Gary	100	75 g	3,000 per month	25 g	20,000,000 per month	....
Huntington	100	50 c	1,300	30 c	.....	....
Knightstown	100	25 g	3,000 per month	8 g	1,000,000 per month	10 g
Lafayette	47	25 g	15,000 per month	10 g	1,030,000	16 g
Mishawaka	100	15 c	8,000 per quarter	7 c	20,000 per quarter	....
Princeton	66	33 g	25,000	13 g	1,500,000	....
West Lafayette	25	30 g	100,000 per ½ year	17½ g	.....	....
Iowa:						
Stanton	100	25 g	20,000 per quarter	15 g	90,000 per quarter	....
Kansas:						
Atchison	25	25 g	15,000 per month	9 g	2,000,000 per month	....
Kansas City	100	25 c	400 per month	6 c	400,000 per month	13
Kentucky:						
Danville	100	65 c	130 per month	9½ c	4,000 per month	17
Paris	....	25 g	1,000 per month	20 g	5,000 per month	....
Maryland:						
Washington Sub. ..) San. Dist. .....)	89	18 g	50,000 per half year	9 g	2,500,000 per month	....
Massachusetts.						
Manchester	100	20 c	.....	20 c	.....	....
Mansfield	85	30 g	30,000 per year	15 g	500,000 per year	....
New Bedford	93	15 g	All but mfg.	10 g	Manufacturing	12½
Somerville	98	12 c	1,000,000 per quarter	8 c	1,000,000 per quarter	....
Wareham	60	20 c	.....	20 c	.....	....
Michigan:						
Adrian	70	32 g	30,000 per month	16 g	120,000 per month	....
Battle Creek	100	14 g	.....	5 g	12,000,000 per month	11½
Crystal Falls	Few	16 c	7,000 per month	5 c	21,000 per month	....
Durand	99	30 g	45,000 per quarter	....	.....	....
Escanaba	82	....	.....	....	.....	....
Grand Haven	97	15 g	1,000,000 per half-year	12 g	3,000,000 per half year	....
Hancock	1	34 c	.....	....	.....	....
Hastings	80	16 c	.....	....	.....	....
Highland Park	99	12½ c	1,000 per quarter	7 c	1,000 per quarter	....
Kalamazoo	100	12½ c	3,000 per quarter	7½ c	10,000 per quarter	....
Manistique	1½	35 g	5,000 per month	5½ g	400,000 per month	6
Marquette	63	10 c	.....	3 c	20,000 per quarter	....
Petoskey	100	....	.....	....	.....	....
Paw Paw	100	25 g	6,000 per quarter	15 g	21,000 per quarter	....
St. Clair	1	15 g	25,000 per quarter	5 g	250,000 per quarter	8
South Haven	95	25 g	10,000 per month	13 g	100,000 per month	....
Wakefield	1	10 g	.....	10 g	.....	10
Minnesota:						
Fairmont	98	25 c	.....	5 c	.....	....
Missouri:						
Caruthersville	100	35 g	2,000 per month	15 g	60,000 per month	....
Chillicothe	95	40 g	5,000 per month	10 g	1,000,000 per month	....
Hannibal	18	....	.....	....	.....	....
Marshall	100	$1.00 g	1,000 per month	1 g	1,000,000 per month	....
Maryville	100	60 c	500 per month	15 c	34,000 per month	....
Trenton	100	40 c	500 per month	7 c	50,000 per month	....
Webster Groves	100	60 g	25,000 per month	32½ g	75,000 per month	....
West Plains	100	50 g	2,000 per month	10 g	30,000 per month	18
Montana:						
Great Falls	7	30 c	100 per month	13 c	10,000 per month	....
Havre	80	30 g	.....	....	.....	....
Libby	5	5 g	1,000,000	4 g	.....	....
Miles City	80	33⅓ g	12,000 per month	8 g	304,000 per month	....
Nebraska:						
Aurora	100	$1.25 g	2,000 per quarter	15 g	25,000 per quarter	....
New Jersey:						
Belmar	97	25 c	.....	25 c	.....	....
Bound Brook	97	45 g	50,000 per quarter	15 g	150,000 per quarter	....
Camden	7	25 g	100 per day	10 g	10,000 per day	13
Egg Harbor	40	35 g	50,000 per year	15 g	1,000,000 per year	....
Hightstown	100	40 g	.....	....	.....	....
Irvington	100	22½ c	10,000 per quarter	11½ c	1,000,000 per quarter	20½
Jersey City	35	9 c	.....	9 c	.....	9

City	Percentage of Services Metered a-	Maximum Rate — Cents per 100 cu. ft. (c) or 1,000 gal. (g)	Maximum Rate — For Consumption Less than	Minimum Rate — Cents per 100 cu. ft. (c) or 1,000 gal. (g)	Minimum Rate — For Consumption More than	Average Rate of all Metered Water—Cents
Montclair (a)	100	29 & 21c	10,000 per quarter	14½ &10½c	1,000,000 per quarter	23.8
Nutley	100	30 c	1,200 per quarter	12½c	10,000 per quarter	24
Ridgewood	60	30 g	100,000 per quarter	15 g	300,000 per quarter	26.5
Rockaway	95	25 g	10,000 per quarter	12 g	200,000 per quarter	....
Westfield	80	....	.....	....	.....	....
New Mexico.						
Deming	80	28 c	900 per month	12 c	2,400 per month	....
New York:						
Cold Spring	75	15 c	.....	15 c	.....	15
Cortland	100	15 c	500 per day	....	.....	....
Dansville	Few	12 g	9,000 per month	2 g	3,000,000 per month	6 g
Fredonia	90	20 g	25,000 per half year	4 g	3,000,000 per half-year	15 g
Johnson City	All domestic	15 c	5,400 per year	10 c	.....	....
Le Roy	90	30 g	20,000 per month	10 g	1,000,000 per month	....
Lowville	98	20 c	1,200 per half year	....	.....	....
Mohawk	60	30 g	10,000 per month	6 g	50,000 per month	....
New York	26	10 c	.....	10 c	.....	10 c
Norwich	99	27.5 c	10,000 per quarter	5 c	80,000 per quarter	....
Ossining	98	20 c	Domestic	10 c	Manufacturing	....
Penn Yan	100	30 g	.....	12 g	100,000 per half-year	16 g
Poughkeepsie	100	20 c	10,000 per quarter	16 c	20,000 per quarter	....
Salamanca	100	55⅓c	300 per quarter	8	60,000 per quarter	....
Saugerties	50	25 g	32,000 per year	5 g	.....	....
Scotia	100	20 c	6,000 per year	8 c	18,000 per year	....
Sidney	Few	6 g	.....	....	.....	....
Solvay	100	15 c	.....	15 c	.....	15 c
Waverly	50	37.5 c	1,600 per half year	5 c	1,000 per month	....
North Dakota:						
Williston	99	20 g	.....	20 g	.....	20 g
Ohio:						
Bucyrus	90	33 c	300 per month	6 c	23,000 per month	....
Lancaster	100	15 c	15,000 per month	10 c	15,000 per month	....
Sebring	....	41 g	12,000 per quarter	10 g	3,000,000 per quarter	....
Oklahoma:						
Claremore	100	30 g	30,000 per month	12 g	500,000 per month	23 g
Collinsville	75	40 g	10,000	20 g	50,000	....
Enid	100	25 g	30,000 per month	15 g	60,000 per month	21.5 g
Mangum	90	20 g	.....	20 g	.....	20 g
Woodward	96.3	33⅓g	3,000 per month	7 g	1,158,000 per month	....
Oregon:						
Eugene	100	15 c	1,000 per month	5 c	27,000 per month	10 c
Marshfield	5	40 c	200 per month	6 c	.....	....
Portland	90	9.5 c	20,000 per month	7.5 c	20,000 per month	....
Pennsylvania:						
Allentown	1.3	40 c	200 per month	3 c	100,000 per month	5 c
Ambler	100	25 g	50,000 per year	17.5 g	25,000 per day	....
Ambridge	100	30 g	50,000 per quarter	12 g	300,000 per quarter	....
Elizabethtown	92	50 g	4,000 per quarter	10 g	250,000 per quarter	....
Gratz	100	1.00 g	2,000 per month	50 g	2,000 per month	....
Knoxville	100	30 g	10,000 per quarter	16 g	50,000 per quarter	30 g
Lebanon	10	....	.....	....	.....	....
McDonald	99	35 g	1,000,000 per quarter	12 g	1,000,000 per quarter	30 g
Monaca	100	42 g	1,000,000 per quarter	14 g	1,000,000 per quarter	28.6 g
Mt. Carmel	65	25 c	2,000 per quarter	12 c	20,000 per quarter	22 c
Mt. Union	10	50 g	4,000 per month	7 g	600,000 per month	....
Ohio Val. Wat. Co. serves 8 com'nities	100	40 g	25,000 per quarter	15 g	300,000 per quarter	30 g
Oil City	100	25 c	5,000 per quarter	12.5 c	15,000 per quarter	....
Palmerton	100	19 c	15,000 per year	7.2 c	45,000 per year	....
Pittsburgh	40	18 g	250,000 per quarter	12 g	750,000 per quarter	....
Reading	100	8 c	.....	8 c	.....	8 c
Sayre	50	50 g	10,000 per quarter	....	.....	....
Sewickley	100	35 g	20,000 per quarter	15 g	200,000 per quarter	....
Somerset	100	33 g	4,600 per quarter	21 g	150,000 per quarter	....
Tarentum	100	35 g	200,000 per quarter	....	.....	....
Titusville	1	12 g	.....	5 g	.....	....
Wellsboro	....b	10 c	50,000 per quarter	4 c	600,000 per quarter	....
West Newton	100	60 g	.....	20 g	.....	40 g
Wilkinsburg	100	24 c	10,000 per month	8 c	400,000 per month	....
Woodlawn	100	30 g	17,500 per quarter	14 g	407,500 per quarter	20 g
Rhode Island.						
East Providence	92	45⅓g	1,000 per day	15 g	10,000 per day	....
South Carolina:						
Bennettsville	100	30 g	25,000 per month	20 g	75,000 per month	27.5 g
Tennessee:						
Erwin	11	30 g	5,000 per month	6 g	600,000 per month	22 g
Shelbyville	12	35 g	5,000 per month	10 g	50,000 per month	16.5 g
Texas:						
Cameron	70	50 g	2,000 per month	10 g	50,000 per month	....
Longview	....	45 g	10,000 per month	14 g	800,000 per month	22 g
Vermont:						
Morrisville	3	15 c	10,000 per half year	6.5 c	40,000 per year	8 c
Virginia:						
Fredericksburg	3	20 g	30,000 per quarter	2 g	10,000,000 per quarter	5 g
Washington:						
Chehalis	95	22.5 c	.....	22.5 c	.....	22.5 c
Hoquiam	85	37.5 c	1,200 per month	15c&6 cd	70,000 per month	13.4 g
Snohomish	2	12.5 c	3,000 per month	5 c	30,000 per month	....
Spokane	100	10 g	.....	....	.....	....
Tacoma	15	10 c	5,000 per month	4 c	30,000 per month	....
Wisconsin.						
Ashland	45	21.5 c	12,500 per month	12 c	50,000 per month	....
Cudahy	100	8 c	100,000 per month	....	.....	....
Green Bay	100	24 ce	500 per quarter	5 ce	100,000 per quarter	....
Marinette	54	40 c	2,500 per month	7.5 c	100,000 per month	25 c
Wyoming:						
Evanston	1	3 g	.....	3 g	.....	3 g

a—Higher rates for pumped service, lower for gravity. b—Industrial and public. d—The 6 ct. rate is for manufacturing, over 50,000 cu. ft. e—Plus service charge.

Use of Water Meters

In the June issue, a summary was given of the reports concerning metering given by the first three hundred cities from which replies to our questionnaire had been received. Since then two hundred and forty-five replies to the questions concerning metering have come in. We give below some figures concerning the entire five hundred and forty-five cities.

Of this number just seventy-five percent report that fifty percent or more of their services are metered. Metering of fifty percent or more of their services is reported by all of the cities replying from Arizona, Florida, Georgia, Idaho, New Mexico, North Carolina, North Dakota, Oklahoma, South Carolina and South Dakota. The same was reported by between ninety-five and ninety-nine percent of the cities of California, Iowa and Kansas; also by between seventy-five and ninety-four percent of the cities reporting from Arizona, Illinois, Indiana, Maryland, Michigan, Mississippi, Missouri, Nebraska, New York, Ohio, Texas, West Virginia and Wisconsin. None of the cities reporting from Utah, Vermont or Wyoming had as many as fifty percent of the services metered.

Chemicals Used in Water Purification

City	Chemicals Used
Alabama:	
Talladega	Liquid chlorine, alum, lime
Arizona:	
Prescott	Liquid chlorine
Tucson	Liquid chlorine (2-3 of supply), copper sulphate (on reservoir walls).
Arkansas:	
Harrison	Liquid chlorine
California:	
Benicia	Hypochlorite, alum (part), soda ash
El Centro	Liquid chlorine
National City	Liquid chlorine, copper sulphate
Pittsburg	Liquid chlorine
San Francisco	Liquid chlorine, copper sulphate, alum (each in part of supply)
Colorado.	
Boulder	Liquid chlorine when necessary
Canon City	Liquid chlorine, alum, lime
Denver	Hypochlorite, liquid chlorine, copper sulphate, alum, lime
Connecticut:	
Bristol	Liquid chlorine
Hartford	Copper sulphate
Florida:	
Live Oak	Liquid chlorine
Georgia:	
Albany	Liquid chlorine
Carrollton	Liquid chlorine, alum, soda ash
Dalton	Liquid chlorine, alum
Newnan	Liquid chlorine, alum, soda ash
Sylvester	Liquid chlorine
Illinois:	
Bloomington	Copper sulphate
Cairo	Liquid chlorine, alum
Chester	Liquid chlorine, alum
Herrin	Liquid chlorine, alum, lime
Johnston City	Liquid chlorine, alum, lime
Lockport	Liquid chlorine
Macomb City	Liquid chlorine, alum
Paris	Liquid chlorine, copper sulphate, alum
Peoria	Liquid chlorine
White Hall	Liquid chlorine, copper sulphate, alum, lime
Indiana:	
E. Chicago	Liquid chlorine, alum
Gary	Liquid chlorine
Princeton	Liquid chlorine, alum, hydrated lime
Whiting	Liquid chlorine, alum
Iowa:	
Atchison	Hypochlorite, alum, lime
Kansas.	
Kansas City	Liquid chlorine, copper sulphate, alum, lime
Kentucky:	
Danville	Liquid chlorine, alum
Paris	Liquid chlorine, alum
Maine:	
Van Buren	Liquid chlorine
Maryland:	
Washington Sub. San. Dist.	Liquid chlorine, alum, lime, occasionally soda ash
Michigan:	
Adrian	Liquid chlorine, alum
Battle Creek	Liquid chlorine
Crystal Falls	Liquid chlorine
Escanaba	Liquid chlorine, alum
Gladstone	Liquid chlorine
Grand Haven	Hypochlorite
Hancock	Liquid chlorine
Highland Park	Liquid chlorine, alum
Manistique	Liquid chlorine
Marquette	Liquid chlorine
St. Clair	Liquid chlorine
South Haven	Liquid chlorine
Minnesota:	
Fairmont	Liquid chlorine, copper sulphate, alum
Missouri:	
Caruthersville	Hypochlorite
Chillicothe	Liquid chlorine, copper sulphate, alum, lime
Hammond	Liquid chlorine, copper sulphate, alum, lime
Marshall	Liquid chlorine
Maryville	Hypochlorite, alum, lime
Trenton	Liquid chlorine, alum, lime
West Plains	Liquid chlorine
Montana.	
Great Falls	Liquid chlorine, alum, lime
Havre	Copper sulphate
Miles City	Liquid chlorine, alum
Ronan	Liquid chlorine, copper sulphate
New Jersey:	
Bound Brook	Liquid chlorine, alum
Hightstown	Lime
Jersey City	Hypochlorite, liquid chlorine
Ridgewood	Liquid chlorine
New York:	
Dansville	Liquid chlorine
Fredonia	Liquid chlorine
Harrison	Liquid chlorine, alum, copper sulphate
Hoosick Falls	Liquid chlorine
Johnson City	Liquid chlorine
Le Roy	Liquid chlorine, alum
Mamaroneck	Liquid chlorine, copper sulphate, alum
New York	Hypochlorite, liquid chlorine, copper sulphate
Norwich	Hypochlorite, copper sulphate, alum
Ossining	Liquid chlorine, copper sulphate
Pelham Heights	Liquid chlorine, copper sulphate, alum
Penn Yan	Liquid chlorine
Poughkeepsie	Liquid chlorine, alum
Saugerties	Liquid chlorine, copper sulphate
Solvay	Liquid chlorine
Waverly	Liquid chlorine, copper sulphate
No. Dakota:	
Williston	Hypochlorite, alum
Ohio:	
Bucyrus	Liquid chlorine, copper sulphate, alum
Sebring	Liquid chlorine, alum
Oklahoma:	
Claremore	Liquid chlorine, copper sulphate, alum, lime
Collinsville	Liquid chlorine, alum
Oregon:	
Eugene	Hypochlorite, alum, lime (sometimes)
Marshfield	Liquid chlorine, alum, lime
Pennsylvania.	
Allentown	Liquid chlorine, copper sulphate
Ambler	Liquid chlorine, copper sulphate
Ambridge	Liquid chlorine
Ashland	Liquid chlorine
Elizabetht'wn	Liquid chlorine, copper sulphate
Knoxville	Copper sulphate
Lebanon	Liquid chlorine
McDonald	Hypochlorite, alum
Monaca	Liquid chlorine
Mt. Union	Liquid chlorine
Ohio Val Water Co. (serves 8 communities)	Liquid chlorine
Oil City	Liquid chlorine
Palmerton	Liquid chlorine
Phoenixville	Liquid chlorine, alum, soda ash
Pittsburgh	Liquid chlorine, soda ash at times
Reading	Liquid chlorine, copper sulphate
Sayre	Liquid chlorine, copper sulphate, alum
Sewickley	Liquid chlorine
Tarentum	Liquid chlorine, alum
Wellsboro	Hypochlorite, copper sulphate, alum
W. Newton	Hypochlorite
Wilkinsburg, et al.	Liquid chlorine, alum, lime
Woodlawn	Liquid chlorine
Rhode Island:	
E. Providence	Liquid chlorine, alum, soda ash
S. Carolina:	
Bennettsville	Soda ash
Tennessee:	
Shelbyville	Liquid chlorine, alum
Texas:	
Cameron	Liquid chlorine, alum
Longview	Liquid chlorine, iron sulphate, alum, lime
Virginia:	
Fredericksburg	Liquid chlorine, alum at times
Washington:	
Chehalis	Liquid chlorine
Hoquiam	Liquid chlorine
Snohomish	Hypochlorite
Tacoma	Liquid chlorine, copper sulphate
Yakima	Liquid chlorine
Wisconsin.	
Ashland	Liquid chlorine
Cudahy	Liquid chlorine
Marinette	Hypochlorite, alum

Water Mains Laid in 1925

City	Municipal (M) or Private (P)	Cast Iron Pipe: Under 6 In. Feet	Cast Iron Pipe: 6, 8, 10 & 12 In. Feet	Cast Iron Pipe: Larger Than 12 In. Feet	Steel Pipe: 12 In. and Smaller Feet	Steel Pipe: Larger Than 12 In. Feet	Other Kinds of Pipe: Kind	Other Kinds of Pipe: Size, Inches	Other Kinds of Pipe: Length Feet
Alabama									
Talladega	M	10,560	....	....	....	....	.....	....	....
Arizona									
Glendale	M	1,800	....	....	....	....	Galvanized	2 in.	800
Tucson	M	3,214	16,865	....	....	....	Wrought iron	2, 1½ & 4 in.	11,723
California									
Anaheim	M	11,000	19,000	2,740	....	....	....	....	....
Benicia	P	....	....	....	....	....	Galvanized	2 & 3 in.	4,800
Burlingame	M	15,840	....	....	3,000	....	....	....	....
Dinuba	M	....	....	....	2,500	....	.....	....	....
El Centro	M	1,000	....	....	....	....	McWane C. I.	2 in.	1,000
Long Beach	M	3,960	30,096	28,248	8,342	....	.....	....	....
National City	—	12,626	11,752	....	....	....	Galvanized	....	1,400
Pittsburg	M	....	....	....	....	....	Wrought Iron	2½ & 4 in.	2,950
San Francisco	—	6,543	43,479	....	....	....	.....	....	....
Ventura	M	15,000	14,000	....	....	2,000	.....	....	....
Colorado									
Boulder	M	1,500	4,000	....	....	....	....	....	.....
Denver	M	174	24,247	16,198	....	14,322	Galvanized	2 & 3 in.	47,702
Connecticut									
Bristol	M	5	5,522	....	....	....	Galvanized	2 in.	1,125
Hartford	M	1,557	58,551	2,213	....	....	.....	....	....
Florida									
Live Oak	M	....	1,700	....	....	....	.....	....	....
Georgia									
Albany	—	2,500	4,200	....	....	....	.....	....	....
Dalton	M	2,800	1,800	....	....	....	.....	....	....
Fort Valley	M	....	5,120	....	....	....	.....	2 in.	3,000
Griffin	M	....	5,900	....	....	....	.....	....	....
Newnan	M	....	1,500	....	....	....	.....	1¼ in.	500
Pelham	P	....	3,500	....	2,000	....	.....	....	....
Sylvester	M	....	....	....	....	....	.....	....	....
Illinois									
Bloomington	M	....	4,200	....	....	....	.....	....	....
Cairo	P	....	3,500	....	....	....	Galvanized	....	....
Canton	M	....	10,560	....	....	....	.....	....	....
Geneva	M	1,600	2,000	....	....	....	.....	....	....
Herrin	M	....	33,000	19,000	....	....	.....	....	....
La Salle	M	1,126	3,200	....	....	....	.....	....	....
Macomb	M	2,000	700	....	....	....	.....	....	....
Morrison	M	1,200	....	....	....	....	.....	....	....
Paris	M	3,000	....	....	....	....	.....	....	....
Peoria	P	3,500	8,150	....	....	....	.....	....	....
Rushville	M	....	2,000	....	....	....	.....	....	....
Sandwich	M	1,000	....	....	....	....	.....	....	....
Watseka	M	2,500	....	....	....	....	.....	....	....
White Hall	M	....	1,900	....	....	....	.....	....	....
Woodstock	M	600	....	....	....	....	.....	....	....
Indiana									
Boonville	M	12,000	960	....	....	....	.....	....	....
Delphi	M	1,650	....	....	....	....	Galvanized	2 & 1½ in.	500
East Chicago	M	....	6,500	....	....	....	.....	....	....
Elwood	P	....	....	....	2,504	....	.....	....	....
Fort Wayne	M	427	40,734	4,905	....	....	.....	....	....
Gary	P	....	....	....	36,088	5,437	.....	....	....
Huntington	M	....	3,754	2,725	1,620	....	.....	....	....
Knightstown	M	....	2,500	....	....	....	.....	....	....
Lafayette	M	3,277	7,748	....	....	....	.....	....	....
Mishawaka	M	2,105	24,291	....	....	....	.....	....	....
Princeton	P	....	4,500	....	....	....	.....	....	....
West Lafayette	P	150	650	....	....	....	.....	....	....
Whiting	M	....	2,400	....	....	....	.....	....	....
Kansas									
Atchison	P	1,700	1,800	....	....	....	Wrought Iron	2 in.	1,000
Kansas City	M	....	35,593	....	....	....	Galvanized Iron	1 & 1½ in.	25,273
Kentucky									
Danville	M	560	....	....	....	....	.....	....	....
Jenkin	P	1,400	....	....	....	....	Galvanized	3 & 4 in.	2,400
Paris	P	....	750	....	....	....	.....	....	....
Maryland									
Hyattsville	M	3,920	126,149	16,315	....	....	.....	....	....
Massachusetts									
Mansfield	M	2,250	....	....	....	....	.....	....	....
New Bedford	M	....	10,141	....	....	....	.....	....	....
Somerville	P	370	4,808	453	....	....	.....	....	.....
Wareham	M	....	3,000	....	....	....	McWane	2 in.	6,000
Michigan									
Adrian	M	....	2,141	....	....	....	Wrought Iron	2 in.	1,347
Battle Creek	M	....	18,280	....	....	....	.....	....	....
Coldwater	M	....	1,800	....	....	....	.....	....	....
Durand	M	2,800			....	....	.....	....	....
Escanaba	M	1,200	....	....	....	....	.....	....	....
Gladstone	M	....	....	....	....	250	.....	....	....
Grand Haven	M	600	2,620	....	....	....	.....	....	....
Hastings	M	....	....	....	600	....	.....	....	....
Highland Park	M	600	4,500	1,800	....	....	.....	....	....
Kalamazoo	M	287	24,713	....	....	....	.....	....	....
Manistique	M	....	475	....	....	....	.....	....	....
Marquette	M	300	....	....	....	....	.....	....	....
St. Clair	M	600	....	....	....	....	.....	....	....
South Haven	M	1,216	1,441	....	....	....	Wrought Iron	1½ in.	1,292
Wakefield	M	5,935	....	....	....	....	.....	....	....
Minnesota									
Fairmont	M	....	600	4,500	....	....	.....	....	....
Missouri									
Caruthersville	M	....	2,000	....	....	....	.....	....	....
Chillicothe	M	....	1,800	....	....	....	.....	....	....
Hannibal	M	....	26,400	....	....	....	.....	....	....
Marshall	M	1,300	....	....	....	....	.....	....	....
Maryville	M	2,000	800	....	....	....	.....	....	....
Webster Groves	P	1,000	....	....	....	....	Galvanized	2 in.	....
West Plains	M	459	....	....	....	....	.....	....	....

City	Municipal (M) or Private (P)	Cast Iron Pipe: Under 6 In. Feet	Cast Iron Pipe: 6, 8, 10 & 12 In. Feet	Cast Iron Pipe: Larger Than 12 In. Feet	Steel Pipe: 12 In. and Smaller Feet	Steel Pipe: Larger Than 12 In. Feet	Other Kinds of Pipe: Kind	Other Kinds of Pipe: Size Inches	Other Kinds of Pipe: Length Feet
Montana									
Great Falls	M	2,242	....	....	812	....	.....	....	....
Libby	P	....	....	....	600	....	.....	....	....
Nebraska									
Aurora	M	....	....	....	....	....	Byers Wrought Iron	2 in.	564
New Jersey									
Belmar	M	2,200	....	....	....	....	.....	....	....
Bound Brook	P	100	3 000	....	....	....	.....	....	....
Camden	M	....	9,000	....	....	....	.....	....	....
Egg Harbor City	M	3,000	....	....	....	....	.....	....	....
Hackettstown	M	....	300	....	....	....	.....	4 in.	400
Hightstown	M	400	400	....	....	....	"Universal"	....	800
Irvington	P	....	26,400	....	....	....	.....	....	....
Jersey City	M	....	10,185	645	....	....	.....	....	....
Montclair	M	....	8,533	....	....	....	.....	....	....
Nutley	M	132	24,421	....	....	....	.....	....	....
Ridgewood	M		20,519						
Rockaway	M	600	2,700	....	....	....	.....	....	....
Westfield	P	....	25,000	....	....	....	.....	....	....
New York									
Cortland	M	300	4,500	....	....	....	.....	....	....
Dansville	M	500	....	....	....	....	Wrought Iron	2 in.	200
Fredonia	M	1,500	3,000	....	....	....	.....	....	....
Hoosick Falls		....	200	....	....	....	Galvanized	2 in.	750
Johnson City	M	4,500	....	....	....	....	.....	....	....
Mamaroneck, Harrison and Pelham Heights	P	....	21.922	....	....	....	.....	....	....
New York	M	218	729 694	96,688	....	3,228	Galvanized	2 in.	26,230
Norwich	P	980	....	....	....	....	.....	....	....
Ossining	M	....	700	....	....	....	.....	....	....
Poughkeepsie	M	....	2.000	....	....	....	.....	....	....
Salamanca	M	....	2,200	....	....	....	.....	....	....
Saugerties	M	1.600	400	....	....	....	.....	....	....
Scotia	M	300	600	....	....	....	.....	....	....
Sidney	M	....	....	....	....	....	S. H. Cast	6 in.	912
Solvay	M	1,000	2,000	....	....	....	.....	....	....
Waverly	M	....	9,845	....	....	....	.....	....	....
Ohio									
Bucyrus	P	....	2,800	....	....	....	.....	....	....
Lancaster	M	5,600	....	....	1.500	....	.....	....	....
Sebring	M	1,100	....	....	2.000	....	.....	....	....
Oklahoma									
Enid	M	....	500	....	....	....	.....	....	....
Woodward	M	300	1,780	....	....	....	.....	....	....
Oregon									
Eugene	M	12,000	11,000	....	5,000	....	.....	....	....
Marshfield and North Bend	P	....	2,640	....	....	....	.....	....	....
Portland	M	73.392	174,768	4,224	....	....	.....	....	....
Pennsylvania									
Allentown	M	....	18,003		....	....	.....	....	....
Ambler	P	3,700	1,400	....	....	....	.....	....	....
Ambridge	M	....	500	....	....	....	.....	....	....
Ashland	M	....	500	....	....	....	.....	....	....
Lebanon	M	....	16,000	....	....	....	.....	....	....
McDonald	P	2,739	15,840	....	....	....	.....	....	....
Ohio Valley Water Co. (Serving eight communities	P	2,000	6,000	1,400	....	....	.....	....	....
Gratz	P	3,480	5,630		....	....	.....	....	....
Monaca	M	300	....	....	....	....	.....	....	....
Mt. Carmel	P	800	1,100	....	....	....	.....	....	....
Mount Union	M	225	....	....	....	....	.....	....	....
Oil City	M	....	626	...	....	....	.....	....	....
Palmerton	P	....	128	....	....	....	.....	....	....
Reading	M	....	20,009	4,685	....	....	.....	....	....
Sayre	P	600	....	....	....	....	.....	....	....
Somerset	M	....	3,000	....	....	....	.....	....	....
Wellsboro	P	2,000	3,500	....	....	....	.....	....	....
West Trenton	P	300	....	....	....	....	.....	....	....
Wilkinsburg	P	320	12,438	4,228	....	....	.....	....	....
Woodlawn	P	2,449	6,800	....	....	....	.....	....	....
Rhode Island									
East Providence	P	400	2,500	....	....	....	Galv. Cement Lined	2 in.	9,000
South Carolina									
Bennetsville	M	....	5,000	....	....	....			
Tennessee									
Erwin	P	....	12,000	....	....	....	Galvanized	1½ in.	5,000
Shelbyville	M	6,400	....	....	6,000	....	.....	....	....
Texas									
Cameron	P	2,000	2,400	....	....	....	.....	....	....
Longview	M	....	3,400	....	....	....	.....	....	....
Virginia									
Fredericksburg	M	....	1,193	....	300	....	.....	....	....
Washington									
Chehalis	M	....	....	....	....	....	Wood Pipe	14 in.	3,000
Hoquiam	M	....	2,000	....	....	....	Creo. Stave Pipe	28 & 26 in.	35,000
Snohomish	M	....			....	....	Wood	12 in.	2,000
Spokane	M	1,837	41,032	....	....	....	Kalamine	6 in.	1,087
Tacoma	M	....	8,470	5,736	3,138	2,160	{ Lock Bar	58 & 64 in.	5,302
							{ Wood	6 in.	7,255
Wisconsin									
Ashland	P	....	2,000	....	....	....	.....	....	....
Cudahy	M	....	3,500	....	....	....	.....	....	....
Green Bay	M	....	12,973	....	....	....	Galvanized	2, 1½ &1 in.	5,828
Marinette	M	....	1,416	....	1,457	....	.....	.....	

Glass Covered Sludge Beds*

Results obtained with open beds at Schenectady, Fitchburg and Plainfield compared with those obtained with covered beds at Marion and Alliance. Ohio. Advantages of covered beds.

Three general methods of air drying of sludge are in use:

Open Fields; In some places it is possible to pump the digested sludge either into pits or to open fields either to dry out naturally or else to be plowed in as fertilizer. This method, while satisfactory from a disposal standpoint, may be open to the serious objection of unsightliness, particularly where the sludge is not covered with earth. Usually the open field method is one more of expediency rather than good practice.

Open Sand Beds; The most generally practiced method for the air drying of sludge in on open sand beds. These sand beds are usually artificially prepared and provided with good underdrainage. A great deal of study has been given to the proper kind of bed construction, yet we believe in the last analysis it is more the character of the sludge than of the drying bed which determines the efficacy of drying both as to time required and quality of cake produced.

Covered Beds; In many sewage treatment plants, it has been found that one of the serious drawbacks to good operation was lack of sludge drying area. Consequently, in many instances it has been necessary to devise ways and means for getting rid of the sludge which often resulted in objectionable conditions around the plant or else has worked a hardship upon the settling tanks because of inability to draw the sludge when necessary. Furthermore, weather conditions frequently are such that the drying of sludge is almost impossible. When this occurs during warm weather, it constitutes a very serious handicap in operation of the settling tanks. Consequently, in 1912 and 1913, when the sewage testing station at Cleveland was in operation, the drying of sludge under glass was attempted with a view in the first place, to cutting down the area required, and in the second place, making the drying independent of the weather. The results obtained in these experiments were so promising that municipal plants built shortly after at Alliance and Canton, Ohio, included glass-covered sludge drying beds. The drying beds themselves are constructed similar to the open beds, but in such a way that they can be covered with standard greenhouse construction permitting ventilation and ready accessibility with industrial track and dump car.

Examples of glass covered sludge drying beds now in service are at Canton, Alliance and Marion, Ohio; Highland Park, Ill; and Boonton, N. J. It is our understanding that others are contemplated in the near future.

*Part of a paper before the New Jersey Sewage Works Association by Floyd G. Browne, superintendent of sewage treatment works of Marion, O., and Frank Woodbury Jones, sanitary chemist with George B. Gascoigne of Cleveland, O.

RESULTS TO BE EXPECTED FROM DRYING BEDS

The object of drying sludge is to reduce the moisture content to such a degree that the sludge can be easily removed from the sand and transported readily to a point of ultimate disposal where it can be either utilized as fertilizer or stored in piles. This means that the dried sludge must be readily handleable, that is, the moisture content must be low enough to permit the sludge to be removed in cakes which will hang together. Soupy or mushy sludge in not handleable, irrespective of its moisture content. The character of the wet sludge has a great deal to do with its behavior when applied to drying beds. A granular sludge with high solids content will dry and drain much more rapidly than will a pasty sludge of equal solid content. Furthermore, there is a wide variation in the per cent of solids found in wet digested sludge. The solids content may vary from as low as 5 per cent to as high as 18 per cent or even more. There seems to be no unanimity of opinions as to what may be considered a satisfactory sludge cake for removal. We have heard it stated that sludge can be applied to a bed and be removed in three days. This, no doubt, is true, but such statements as a rule do not include the moisture content of the sludge applied nor the depth to which it was placed upon the bed. Generally speaking, sludge with solids content of between 30 and 40 or, if you please, a moisture content of between 70 and 60, may be considered a satisfactory sludge for removal. Any sludge with a greater moisture content is questionable, that is as regards its ease of handling. Consequently, for the purpose of this discussion, we will consider that for good operation, a sludge should be reduced to approximately 65 per cent moisture before being considered removable. Any further reduction of moisture is just that much gain, for the drier the cake the less the weight to be moved and the more easy it is to be handled.

RESULTS WITH OPEN AND COVERED BEDS COMPARED

The efficacy of a sludge drying area may be measured in two ways. First, how much sludge can be handled in a year, and second, how quickly will it dry. It is obvious that on an open bed the drying of sludge is dependent upon weather conditions. Furthermore, we know that when digested sludge containing large quantities of gas is placed upon an open bed and immediately

thereafter a rain occurs, the gas is beaten out, the sludge loses much of its buoyancy and consequently becomes a more compact, or less porous mass. This obviously will require a longer time to reach a removable condition.

In the next place, winter drying of sludge in this climate on open beds is practically out of the question, due not only to the freezing, but also to the fact that once snow falls the beds are out of commission until the snow disappears and the beds are dried out.

In the plants at Schenectady, N. Y., Fitchburg, Mass., and Plainfield, N. J., we have fair examples of what can be accomplished in the air drying of sludge on open beds. There are other places at which the data may be just as complete which perhaps would tell a different story, but with these we are not so familiar. At Marion, Ohio, during the past year, we have had an opportunity to observe the operation of glass-covered beds, and an attempt will be made to show the possibilities in each case. Furthermore, some data are available for the past four years, concerning the operation of the glass-covered sludge beds at Alliance, Ohio.

I might digress at this point to speak of the information we get at Alliance, or rather, the lack of information we have there, which illustrates how particularly essential it is, if you please, to have some good operating data. We know how much sludge is taken up by the beds, how much in a manner is going on them, but not enough to know what is really being accomplished there with the sludge in the matter of treatment.

During the past five years at Plainfield, there have been treated on open sludge drying beds, totaling some 18,040 square feet, approximately 4,000 cu. yds. of wet sludge per year, and the number of dryings has amounted to not more than seven per season.

The solids in the wet sludge have varied from 5.5 to 7.5 per cent. We believe that this represents the maximum possible usage of the available sludge bed area at this plant.

At Fitchburg during the past 10 years, there has been treated on 18,315 square feet of sludge drying area an average of 3,234 cubic yards of wet sludge or 343.5 tons of dry solids. This does not represent all the sludge produced at the plant. About six dryings per year is all that have been possible, some years only five. The sludge has contained a yearly average of from 8.41 to 16.94 per cent of solids, averaging for the ten years 13.00 per cent. The sludge as removed had yearly averages varying from 43.10 to 63.99 per cent solids, averaging 51.97 per cent. The depth of application was from 10 to 12 inches or more.

At Schenectady the records show that during the past year, 1,862 cu. yds. of dried sludge have been removed from some 24,320 square feet of sludge drying area. No data are given as to the number of times the beds were used but apparently the area has been adequate. Data on the old beds show as many as ten fillings and as few as seven per year, depending upon the weather. The sludge was thin and applied to a depth of 8 to 10 inches.

The results at Plainfield and at Fitchburg indicate the possibility of drying 0.22 and 0.176 cubic yard of wet sludge per year per square foot of drying area, respectively. Plainfield data indicate, however, the disposal of only about 250 tons of dry solids per year, or 0.014 ton per square foot, whereas at Fitchburg, the average has been approximately 350 tons, or 0.019 ton per square foot per year. It is to be mentioned, however, that the variation from year to year was considerable, due to weather conditions.

At Schenectady, an experiment was conducted during September and early October, 1925, to determine the rate of drying on open beds. Sludge was applied on different beds to depths averaging 6, 8, 10 and 12 inches. The results indicate that 6 inches of a 95 per cent moisture sludge can dry to 65 per cent moisture in 5 days, 8 inches of 96 per cent in 7 days, 10 inches of 94 per cent in 12 days and 12 inches of 94 per cent in 18 days of summer temperatures between 78° Fahrenheit and 36° Fahrenheit with light winds and practically no precipitation.

Experiments conducted at Marion, Ohio, at various times during the past year on glass-covered beds, indicate that 6 inches of 92 per cent moisture sludge can be dried to 65 per cent moisture in 4 days, 8 inches of 94 to 91 per cent in 9 days, and 10 and 12 inches of 93 per cent in about 15 days.

It was noted that on both open and closed beds, the greatest reduction in moisture occurred in the first 24 hours, which tends to show that subsequent reductions are more the effect of evaporation than of drainage.

At Alliance, Ohio, using glass-covered sludge drying beds with a partially digested sludge of rather poor quality, the following results were obtained on 10,240 square feet of drying area, dosed to an average depth of six inches.

	Cu. yds. Wet Sludge Applied	Number of Fillings
1920	2,525	14.
1921	3,560	23
1922	3,015	19.5
1923	2,910	19.5
Average	3,000	19.0

This shows that there have been an average of 19 fillings a year and that the beds can be used practically all the year round.

At Marion during the past year, 2,500 cubic yards of wet sludge averaging 7.5 per cent solids or 92.5 per cent moisture, were applied to the drying beds in 10 pumpings. The drying beds have not been utilized to their maximum extent, due to the fact that means for transporting the sludge were not always available when required. The sludge as removed from the beds had a solids content varying between 97 and 27, averaging 50 per cent. If the beds had been cleaned when the sludge was first ready for removal, the data indicate that the actual time necessary to dry the 2,500 cubic yards to a satisfactory removable condition would not have exceeded 120 days at the most. This indicates further, that 7,800 cubic yards of wet sludge averaging 7.5 per cent solids could be dried to at least 35 per cent solids

or 65 per cent moisture in one year on 12,580 square feet of drying area or about 0.60 cubic yard per square foot per year. On this basis each square foot of covered sludge drying area can dispose of at least three times the volume of sludge dried on open beds. Or, in other words, for a given plant, only one-third the open bed area is required if the beds are covered.

OPTIMUM DEPTH TO APPLY WET SLUDGE

It is obvious that the less the depth of wet sludge the more quickly it will dry. However, it is equally obvious that if sludge be applied too shallow the available drying area will be used up without getting rid of very much sludge. Furthermore, practically just as much sand will be taken away with a thin cake as with one somewhat thicker, and the man-hours required to remove a thin cake are almost as high as for the removal of a thick cake. Furthermore, it is necessary to determine at each plant the depth to which the sludge produced can be most economically and effectively applied. This means that the sludge should be applied to such a depth that it will produce a fairly thick cake and at the same time dry to such a point that it can be readily handled on removal, thus making the bed available for the necessary wet sludge from the tanks to maintain a proper working balance. In other words, the sludge beds should be so operated that the digested sludge from the tanks can be taken care of when necessary to assure their efficient operation. This optimum depth will usually be found to be between 12 and 8 inches, probably about 10 inches. In a covered bed where conditions can be somewhat controlled, this optimum depth can be more readily determined.

AREA OF SAND BEDS REQUIRED

In the earlier installations of sludge beds, the area allowed amounted to perhaps about 1-2 square foot per person. It is now generally recognized that in most cases this figure is too low and present designs for open sludge beds usually make an allowance of from 0.75 to 1.00 sq. ft. per person, the latter figure being preferable. In the covered sludge drying beds it is realized that less area is required, and judging from the possibilities indicated by results obtained at Marion and elsewhere, the figure of about 1-3 square foot per person seems justified. It is realized of course, that the amount of sludge to be handled at any particular installation will depend on the concentration of the sewage to be treated and also upon the reduction effected by digestion. Usually a well digested sludge should not amount to more than 1,000 gallons or 5 cubic yards per million gallons of sewage treated. In some instances it is true that this figure is exceeded while in others it has been less.

RELATIVE COST OF OPEN AND COVERED BEDS

The cost of sludge drying beds will depend upon the cost of sand in any particular locality. For the actual drying space, whether open or covered, the cost per unit area should be the same. The cost of covering may be stated, judging from actual construction, to be approximately $1.60 per square foot, while the cost of the sand beds, including industrial track, is approximately $1.00 per square foot. Consequently if the area of covered beds can be made 1-3 that of open beds, it is seen that the net cost per capita is less for covered beds.

Besides the construction cost there is to be considered the maintenance cost. The question arises as to the possibilities of breakage of glass. During the past year the upkeep of the Marion plant has been practically nothing, and we are informed that at Alliance during the past 5 years the damage has been relatively small. It is conceivable that with hail and tornadoes the damage may be very large. However, these matters can be covered by insurance at relatively a nominal cost. Taking all factors into consideration, the total annual costs of both types may be taken as being on a par with the advantage, if any, in favor of the covered beds.

ADVANTAGES OF COVERED BEDS

The greenhouse covered sludge beds have several distinctive advantages. In the first place, there is the matter of compactness. It has been stated that the area required for covered beds is 1-3, or less, of that required for open beds. This means that the entire working space is spread over a relatively small area. Furthermore, engineers and city officials are now stressing the advantages of maintaining sewage treatment works in such a manner that they will be attractive to the eye. A greenhouse covered sludge drying bed in this respect is particularly favorable.

The real criterion of how much sludge bed area you need depends upon how much area you need to get rid of a pound of dried solids. About two years ago we were called in to rescue a sewage plant which was said to be on its last legs in a little bit of a town. There was a great deal of agitation about this plant, particularly from a farmer who had a pasture bordering on the stream into which the effluent discharged. One of the first recommendations for this plant was to clean it up. There was nothing wrong in the design of the plant and it seemed adequate for the purposes, so we managed to get hold of a fellow who would take an interest and he painted the buildings, trimmed up the dikes, kept the banks clean and got the old sludge that had piled up and hauled it away, and I have been told that the fellow who knocked the plant the hardest is now one of its boosters, simply because the plant now appears to be well taken care of.

As indicated above, the cost of a covered sludge drying bed, all things considered, may be estimated as being either less or at least on a par with that of open beds.

The greatest advantage of the glass-covered sludge bed, however, is the fact that its operation is relatively independent of weather conditions. This applies not so much because it is possible to operate the beds during the colder months, as to the fact that during the summer, when it is necessary or at least desirable to get rid of large quantities of sludge, that regular schedules can be maintained since, ex-

cept for humidity, the wet weather will not affect the drying. Most of us know that it is very discouraging to have all of our available sludge bed area filled up with nicely digested sludge only to have a 24 hour rain beat it down into a compact, soggy mass. With covered beds such rains are caught on the roof and pass off into the gutters, while the sludge remains unaffected. Then, too, the temperature inside a covered bed is considerably higher than in the open air, and there is no disadvantage due to lack of ventilation. In winter the temperature inside is usually 15 to 25 degrees higher than outside, so that freezing of the sludge is relatively slight. While the length of time for drying is longer in winter than in summer, it is entirely feasible.

Florida Water Supplies

Only ten of one hundred and sixty-six supplies use surface water. High hardness and sulphur contents general. Purification plants rapidly increasing in number and excellence.

The water supplies of most of the cities and smaller communities of Florida formed the subject of a paper before this year's convention of the American Waterworks Association by E. L. Filby, chief engineer of the state health department. He commented upon the fact that, although Florida contains more than 30,000 lakes varying in size from Lake Okeechobee, the largest fresh water lake entirely in the United States, down to the smallest pond, and hundreds of springs, and has an average rainfall of 53 to 59 inches, the state obtains little of its supply from the surface, but most of it from wells. In a tabulated statement in the paper, Mr. Filby listed only ten surface supplies in a total of 166. The others include 126 from deep wells, 26 from shallow wells and four from springs.

This preponderance of well supplies is perhaps more remarkable when we consider that most of them are very highly impregnated with gases and minerals. "Geologically, all rocks in Florida are sedimentary and were for the most part deposited beneath the ocean, therefore containing salt sea water. The principal source of springs and deep well supplies is the soft, porous Vicksburg limestone. Large underground channels must exist, but the rock is ordinarily honeycombed with small pores and passageways. The Vicksburg limestone is often subdivided into three formations—Ocala limestone, peninsula limestone and Marianna limestone. Suffice to say, practically all deep-seated supplies of any importance or quantity are taken from the Vicksburg group of limestones."

In Tallahassee, the water has a hardness of 130 p.p.m; at Live Oak, 195 p.p.m., and at Lake City 200 p.p.m. with the presence of sulphur in the form of H_2S. Jacksonville water from wells 750 to 1,200 feet deep is highly laden with H_2S, which is largely removed by aeration, has a temperature of about 82 degrees and a hardness of 300 parts. This city is expecting to change to a surface supply. St. Augustine for years used sulphur water with a hardness of 544 to 714 p.p.m. and a chloride content of 154 to 635, but has recently changed to shallow well water with a hardness of 250 and chloride content of 50, which is aerated and chlorinated.

In the entire northern part of the state, 360 miles east and west, and 50 miles south from the north border, there is not a single surface supply, although there are many streams available. Most of the springs are as objectionable as the wells. In Sulwanee County a spring discharges 52,000 gallons per minute of hard sulphur water; at Green Cove Springs a spring discharges sulphurous water of 78 degrees temperature. At Panacea a very large spring of soft water is used for medicinal purposes.

Daytona obtains a supply from eight wells which is aerated to remove sulphur and treated with lime to reduce hardness. An entirely new system for the greater city of Daytona Beach is being designed by Metcalf and Eddy. New Smyrna's supply has a hardness of 840 p.p.m., chloride content of 1,500 parts and total solids of 2,940 parts. At Titusville the water has a hardness of 230 parts. At Fort Pierce, the hardness is 332 parts and the water sulphurous. A new three million gallon rapid sand filtration and iron removal plant is being built to use surface water. All water for West Palm Beach is taken from a series of lakes or savannas just west of the city in sand dunes. This water is highly colored and is treated with alum, aerated, filtered and chlorinated. The color is reduced from 102 to 23. Shallow wells are used by the West Palm Beach Water Company to help on peak loads, but the present six-million-gallon plant is being enlarged to twenty million gallons under the direction of Mr. Pirnie of Hazen and Whipple, and when this is complete the wells will be abandoned. Miami is supplied largely from shallow wells with water having about 250 p.p.m. permanent hardness and a color of about 60. It is provided with a lime softening filtration plant of 10 million gallons capacity designed by Alvord, Burdick, and Howson, with Charles P. Hoover as consulting chemist. Dorr clarifiers and equipment are used and the water is carbonated and then filtered.

Water for Key West is obtained from Homestead, the site of one of the Florida East Coast Railway's softening plants, where the softened water is placed in tank cars and sent by rail 122 miles to Key West, where no fresh water is available except in the form of rain. A plan has practically been decided upon to lay a pipe line from Homestead to Key West along the railway's right-of-way or along the new oversea highway now being constructed. For the entire southern part of the state, Lake Okeechobee and the Everglades drainage canals are looked to by many as the future source of water supply.

Passing to the west coast, we have Ft. Meyers

with a sulphurous supply with a hardness of 650 parts and over 700 parts of chloride. Other cities in the vicinity including Punta Gorda, Bradentown and Sarasota, have equally unsatisfactory supplies. "Here is an ideal location for a district water supply, taken from the head waters of the Manatee river, with a color removal and softening plant to serve Bradentown, Palmetto, Manatee, Ellenton and possibly Sarasota." Tampa has arranged for an up-to-date supply, as described in PUBLIC WORKS a few months ago. The supply of St. Petersburg averages 400 parts hardness and the city is investigating a new supply. Okeechobee City on Lake Okeechobee has just completed a new filtration plant of the rapid sand type which will be the first real test plant used for this lake water. Lime, alum and chlorine will be used. Color removal and occasionally vegetable growths form a problem to be solved.

Coming north through the ridge country are many small towns using deep well supplies, the water from which usually has a hardness of between 100 and 200 parts. Sulphur is not a problem and bacterially the water is excellent. Thousands of lakes are scattered over this district but none are used for public supplies until we come to Orlando which takes her supply from Lake Ivanhoe, using rapid sand filters and chlorine. This is the only filter plant in this section of the state and is under chemical and bacteriological control. Six miles east of Ocala is Silver Springs, said to be the largest in the world, the flow from which is about 385,000 gallons per minute and creates a river navigable at its source. The water is crystal clear, objects being seen readily at a depth of 80 feet, and is not very hard. Another spring nearby has a flow of 350,000 gallons per minute. Palatka obtains two supplies, piped separately, a soft supply and a hard, from wells and a spring.

The state board of health maintains a laboratory at Jacksonville for the purpose of making bacteriological examinations of water supplies, for which no charge is made, but the cities are required to purchase shipping cases which the state obtains at a special price of $14.50. Where the cities do not own their shipping cases, field inspectors collect samples and ship them in state board of health boxes. Samples are shipped iced and usually received at Jacksonville within 24 hours, special arrangements with the express companies being made.

Diesel Stand-by Plant at Portland, Michigan

The village of Portland, Mich., operates a 300 k.w. hydro-electric plant located on the Grand river, about two miles from the village. Shortage of water makes it necessary at certain periods of the year to use standby equipment. The first expedient was a 150 k.w. steam-driven unit in the power house of a local manufacturing concern. As periods of low water became more frequent and of longer duration, and as the cost of power by this standby plant was 10c per k.w.h., the village investigated the possibility of a more economical source of power and decided to install a Diesel engine, and one of this type of 200 horsepower coupled with a 150 k.w. generator, together with accessories such as oil pumps and switchboard, was furnished under contract by the DeLa Vergne Machine Co., which furnished its own make of Diesel engine and a Westinghouse generator.

This plant was installed about two years ago. F. L. Jenkins, manager of the plant, reports that the replacements during that time have amounted to $59. All main bearings are lubricated by a pressure system which has operated without failure so far. All oil is reclaimed, the operation consisting of heating and agitating a mixture of 18 gallons of used oil, 18 gallons of water and 4 pounds of Oilite, the entire operation requiring about one-half hour.

The Diesel installation is located at the pumping station and operated by the engineer of that station, the attention required consisting of an occasional oiling and putting the unit into service when desired.

The engine has carried a 50 per cent overload for 2½ hours without overheating and made one nonstop run of four weeks. In the two years of operation it has been called upon for 569,135 k.w.h. standby service, operating 6,176 hours and consuming 1,078 barrels of fuel oil and 376 gallons of lubricating oil and has cost $88.12 in maintenance and repairs. It has been operating at a load factor of 61.4 per cent and for 33 per cent of the time, making the station factor slightly over 20 per cent. The cost per k.w.h. delivered to the station busses has been 1.694c or 8.3c less than the former cost of standby service.

In making a financial statement of the plant, Mr. Jenkins states that they depreciate the plant on the basis of 20 years life. On this basis, and using the figures obtained while running with a station factor of about 20, as described above, it is calculated that should the station factor rise to 50, the cost per k.w.h. would be slightly under 1.2c.

The plant is using 34° Beaumé fuel which runs about 7.12 pounds per gallon. With the generator operating at 61.4 per cent of its rated load, at which its efficiency is under 80, they succeeded in getting 10.18 k.w.h. per gallon of fuel oil which is calculated to be equivalent to 1 h.p. for every 0.415 pounds of fuel, the guarantee having been for 0.5 pounds.

The cost of the installation was $21,200, of which the engine cost $12,105, the foundation and material $2,395, generator, $1,930, switchboard $947, labor, $2,338, engineering $423, oil pump and piping and tank $713, and the remaining $200 for wiring and miscellaneous items. From October 1, 1923, to November 30, 1925, 1,078 barrels of fuel oil were used, the average cost of which was $3.11½ or a total cost of $3,358 for an output of 569,135 k.w.h. or 0.059c per k.w.h.

In figuring the operating cost of the plant, depreciation is charged at $1,060, interest at $667.81 and insurance at $212. This gives the fixed charges per k.w.h. as 0.738c. Operating labor at 28c an hour gives 0.304c; lubricating oil at 51c a gallon gives 0.034c; and Oilite, 0.003c. Maintenance and repairs have totaled $59 for material, $29.12 for labor. With an assumed $25 a year for miscellaneous expenses, the total cost per k.w.h. is figured at 1.694c.

Recent Legal Decisions

STATUTORY PROVISION AND CONTRACT AGREEMENT AGAINST SUBLETTING PUBLIC CONTRACT WITHOUT STATE'S ASSENT

Section 43 of the New York State Finance Law provides that state contracts shall not be assigned, sublet or otherwise disposed of without the written consent of the department or official awarding it. A highway contract contained an agreement by the contractor not to assign without such consent. The Court of Claims holds, Cooper Snell Co. v. State, 125 Misc. 715, 211 N. Y. S. 811, that an assignment of the contract to a contractor who furnished the materials, labor and services for the execution of the contract, not filed with the highway department nor consented to by it in writing, was illegal and void as far as giving the assignee any right to maintain an action against the state for the value of the materials, etc., furnished was concerned, the assignee having no privity of contract with the state, and its claim for redress for any grievance being against the principal contractor.

TREATMENT OF GUARANTY PERIOD IN ROAD CONTRACTOR'S INCOME TAX RETURN

A highway contractor reported its profit from a road contract on the completed contract method under Regulation 45 of the Bureau of Internal Revenue, art. 36, instead of on the alternative apportionment method of reporting profits in the taxable year in which the work is finally accepted, under Regulation 62, art 36. The federal district court for western Pennsylvania holds, Thomas Cronin Co. v. Lewellyn, 9 F (2d) 974, that the date of completion and not the date of acceptance of the work was the correct date for determining profits.

The contractor might go through the guaranty period without spending a cent. If such expenditures should be made during the guaranty period, they might properly be deducted from the income in the year in which they were made.

MISTAKE IN SPECIFICATIONS AS TO LOCATION OF SANDSTONE LEDGE—COUNTERCLAIM BY STATE FOR COST OF COMPLETION

The New York Appellate Division, Fred. E. Gross & Son v. State, 214 App. Div. 386, 212 N. Y. S. 222, on appeal from the State Court of Claims, holds that, where a state highway contractor's proposal recited that it had personally inspected the sources of supply, and that it waived all right to plead any misunderstanding, and the contract recited that the contractor was fully informed of all the conditions affecting the work by personal investigation and not from estimates, and that it could make no claim against the state by reason of estimates, tests or representations of any officer or agent of the state, it could not afterwards complain of a mistake in the state's specifications as to the location of a sandstone ledge in the absence of a showing of bad faith.

The state counterclaimed under Highway Law, Section 132, providing that after cancellation of a contract "any excess in the cost of completing the contract beyond the price for which it was originally awarded shall be charged to and paid by the contractor failing to perform the work." It was held that the state could not recover, the evidence showing nothing more than that the work was "near completion," while the word "cost" both under the statute and the contract, must mean expenditure, which could not be ascertained until completion, both contracts being in all essentials unit price contracts.

JURISDICTION OF CITY COMMISSION OVER OPERATION OF STREET RAILWAYS

The Connecticut Supreme Court of Errors holds, Connecticut Co. v. City of New Haven, 130 Atl. 169, that although the city of New Haven had power in 1893 to make a regulation requiring two trainmen on each street car, the matter is now within the exclusive jurisdiction of the Public Utilities Commission under the Public Utility Act of 1911, now Gen. Stat. c. 191, which, particularly in section 3621, shows an intent to place the exclusive jurisdiction over the operation of street railways, aside from mere local regulations, in the Commission.

STREET RAILWAY'S STATUTORY DUTY TO REPAIR STREETS SUSPENDS CITY'S LIABILITY FOR DAMAGES FOR DEFECTS

Connecticut Pub. Acts 1921, c. 314, imposes a liability on a street railway for damages caused by a hole made in the repair of its tracks, and not on the city, in view of Conn. Gen. St. Sec. 1407, placing upon towns the duty to repair their highways, except where that duty belongs to some particular person. No supervisory duty was imposed by statute on the city. The moment the duty to repair a portion of the highway arose in the street railway company, the city's duty ceased as to that portion of the highway, and would not revive until the street railway's duty ceased.—Coletti v. City of Bridgeport, (Conn.) 130 Atl. 175.

MATERIALMAN'S ACTION UNDER PENNSYLVANIA STATUTE PREMATURELY BROUGHT BEFORE FINAL SETTLEMENT BETWEEN CONTRACTOR AND STATE

The Pennsylvania Supreme Court holds, Commonwealth v. Piel Const. Co., 130 Pa. 261, that, under Pa. Act May 31, Sec. 13 (P. L. 468), as amended by Act May 16, 1921 (P. L. 650), Pa. St. Supp. 1924, Sec. 19207, an action by a materialman for materials and supplies used in making a state highway, brought in the name of the Commonwealth for his own use and benefit, on the road contractor's bond, was prematurely brought although there had been a completion of the contract, where there had been no final settlement between the contractor and the Commonwealth.

ZONING ORDINANCE HELD INVALID

The New Jersey Supreme Court holds, Heller v. Village of South Orange, 130 Atl. 534, that a zoning ordinance, providing that "no part of a building shall be higher above the curb level than the distance it sets back from the street line of the street on which it faces and the front yard set back distance to the main front wall shall not be less than 25 feet, except that on a corner lot the set back distance from one street line may be reduced to not less than 15 feet" is not a valid exercise of the police power, but a taking of private property for public purposes without just compensation being made to the owner.

WITHHOLDING OF BUILDING PERMIT HELD UNJUSTIFIED

The New Jersey Court of Errors and Appeals holds, H. Krumgold & Sons v. Mayor, etc., of Jersey City, 130 Atl. 635, that the withholding of a building permit to the owner of lands to erect stores with apartments above, on a street zoned for residential purposes, on the ground that there is a high school in the vicinity, and the erection of two other schools is in contemplation, and that thousands of children must necessarily pass the stores in attending the schools, is not justified under N. J. Laws 1924, c. 146, (P. L. 1924 p. 324), as being a proper exercise of the police power for the promotion of the public health, safety, morals and general welfare.

CONSTRUCTION OF RESTRICTIVE CLAUSE IN WATERWORKS CONTRACT WITH OPTION OF PURCHASE BY CITY

A clause in a contract between a city and a water company, which gave the city the option to purchase the waterworks, provided that the city, in its use of the water to be delivered or purchased, could supply its own inhabitants and those of designated municipalities, but that the city should not supply public or private corporations outside of such designated territory. The city availed itself of the option of purchase. The New Jersey Court of Errors and Appeals holds, East Jersey Water Co. v. City of Newark, 130 Atl. 557, that the restrictive clause referred only to the period covered by the option, and did not restrict the city's use of the water after its purchase of the waterworks.

CLAIM FOR REPLACING WORK DONE UNDER ADVERSE WEATHER CONDITIONS

A contractor on public work for a municipality claimed to have been directed by the municipality's agents to proceed with the work under weather conditions which normally would and actually did spoil part of the work. This part was rejected by the engineer, and the contractor did it over again as a prerequisite to obtaining a certificate and payment. After final certificate and payment, and acceptance of the work as amended, the contractor brought suit for moneys claimed as due for doing over the rejected part. The New Jersey Court of Errors and Appeals holds, Overland Const. Co. v. Village of Ridgewood, 130 Atl. 559, that the contractor was estopped from claiming payment for the work done over after having accepted payment as in full pursuant to the contract and certificate.

WHETHER RENT OF MACHINERY FALLS UNDER MECHANIC'S LIEN STATUTE AS LABOR OR MATERIAL DEPENDS ON LANGUAGE OF STATUTE

The Kansas Supreme Court holds, Road Supply & Metal Co. v. Bechtel-Heimer, 240 Pac. 846, that the rent or value of the use of machinery, tools and equipment used in constructing public work is neither labor nor material within the meaning of the Kansas Mechanic Liens statute. "Labor," as used in that statute, refers to physical labor or the specific kind of labor mentioned therein. "Material," within the meaning of the statute, is that which enters into, becomes a part of, and remains with the completed work. The court distinguished cases cited from federal and Oregon and Washington courts, holding that the rental or value of the use of machinery and equipment should be regarded as material entering into the completed work, as being under statutes differing materially from the Kansas statute, and which specifically state that the use of machinery shall be regarded as material, or are fairly open to that interpretation.

MUNICIPALITY MAY TERMINATE LIGHTING CONTRACT SPECIFYING NO TERM

The Ohio Supreme Court holds, Ohio Public Service Co. v. State, 149 N. E. 129, that where the contract between a municipal corporation and an electric lighting company is silent as to the duration of the franchise, it is not perpetual, but the duration is simply indeterminate, existing only as long as the parties agree thereto. A municipal corporation may therefore voluntarily terminate its obligation under such a contract and wholly withdraw therefrom.

ILLEGAL ITEM IN ENGINEER'S ESTIMATE OF IMPROVEMENT COST WILL NOT DEFEAT ASSESSMENT IN ABSENCE OF COLLUSION

In a suit to enjoin the collection of special paving assessments, the Oklahoma Supreme Court held, City of Beggs v. Kelly, 238 Pac. 466, that the fact that the engineer's estimate of the cost of proposed improvements is illegal because of the inclusion therein of an improper item in the amount of 15 per cent. did not justify injunctive relief to taxpayers in the absence of collusion or fraud on the part of the successful bidder, where the proceedings were regular on their face and the contract had been let after public advertisement. The Oklahoma statutes provide that improvement bonds issued thereunder shall in no event become a liability of the city, which is merely the collection agent for the indebtedness. Even had the bonds been sold below par, the taxpayers could not assert the invalidity of the assessment after having received the benefit of the completed pavement. It was also held that this rule has no application to county or municipal bonds levied pursuant to a vote of the electors, which are the direct obligation of the municipality.